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for DISTORTION and BRIDGE MEASUREMENTS at 2 to 15,000 CYCLES

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THIS highly stable oscillator with unusually low distortion is of the resistance-tuned type and operates on the inverse feedback principle developed by General Radio.

The Type 1301-A Low-Distortion Oscillator is especially suitable as an a-f power source for bridge use, for general distortion measurements, to obtain frequency characteristics and to make rapid measurements of distortion in broadcast transmitter systems.

FEATURES

- **WIDE FREQUENCY RANGE** — 20 to 15,000 cycles (with Range Extension Unit, 2 to 15,000 cycles)
- **CONVENIENT TO USE** — 27 fixed frequencies, selected by two push-button switches in logarithmic steps — any desired frequency between steps obtained by plugging in external resistors
- **THREE OUTPUT IMPEDANCES** — 600-ohm balanced to ground; 600-ohm unbalanced; 5,000 ohm unbalanced
- **EXCEPTIONALLY PURE WAVEFORM** — Distortion not more than the following percentages: with 5,000-ohm output 0.1% from 40 to 7,500 cycles; 0.15% at other frequencies. With 600-ohm output 0.1% from 40 to 7,500 cycles; 0.25% from 20 to 40 cycles and 0.15% above 7,500 cycles
- **HIGH STABILITY** — Frequency is not affected by changes in load or plate supply voltage. Drift less than 0.02% per hour after a few minutes operation
- **ACCURATE FREQUENCY CALIBRATION** — Adjusted to within 1½% ± 0.1 cycle
- **NO TEMPERATURE OR HUMIDITY EFFECTS** — In ordinary climatic changes, operation is unaffected

TYPE 1301-A LOW-DISTORTION OSCILLATOR $395.00

- *The normal range of this oscillator is 20 to 15,000 cycles. The Range Extension Unit (above) lowers this range by a full decade to 2 to 15 cycles, greatly extending its usefulness to frequencies considerably below those heretofore practicable.*

With its very high stability, unusually low distortion and many operating conveniences, the Type 1301-A Low-Distortion Oscillator fills a universal need in distortion and bridge measurements.

TYPE 1301-P1 RANGE EXTENSION UNIT $70.00

GENERAL RADIO COMPANY

Cambridge 39, Massachusetts

90 West St., New York 6 — 920 S. Michigan Ave., Chicago 5 — 950 N. Highland Ave., Los Angeles 38

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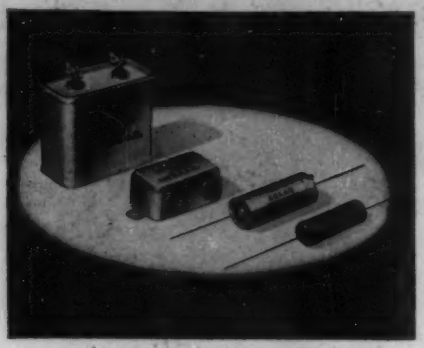
The Solar System

electronics edition • July 1948

POLYSTYRENE FILM CAPACITORS



POLYSTYRENE plastic-film capacitors are a Solar specialty product for unusual circuit applications. Polystyrene dielectric capacitors have exceptionally low power factor, very high insulation resistance, excellent temperature-capacitance stability and unusually low dielectric hysteresis.

Typical applications for polystyrene capacitors include timing and integrating capacitors, r-f padding capacitors, coupling capacitors in high gain amplifiers, etc.

Polystyrene capacitors are unique in their ability to store a charge for a long period of time and then discharge it instantly and completely.

Four case designs are standard for Solar polystyrene capacitors at standard working voltage of 400 wvdc:

1. *Cardboard Tubulars—Type SDP.* These tubular capacitors are housed in wax-impregnated kraft tubes with wax end seals. Terminals are tinned copper leads. Capacitances range from 50 mmf to .1 mf.
2. *Metal Tubulars—Type XTIPWV.* These are insulated section hermetically sealed metal tubulars with outer plastic tube to avoid leakage and at the same time provide an insulating cover for the capacitor container. Capacitances range from .001 to .1 mf.
3. *Drawn Metal Case—Type XDPG.* These "bath-tub" can units are hermetically sealed with glass solder-seal terminals to insure maximum insulation resistance. Capacitances range from .01 to .5 mf.
4. *Fabricated Metal Case—Type XLPG.* These rectangular metal cased capacitors are also hermetically sealed with glass solder-seal terminals to insure maximum insulation resistance. Capacitances range from .25 to 10.0 mf.

Complete descriptive information and standard ratings are given in catalog bulletin SPD-600. Write today for your copy.

Solar Manufacturing Corporation
1445 Hudson Blvd., North Bergen, N. J.

SOLAR CAPACITORS
"Quality Above All"

BUSINESS BRIEFS

By W. W. MacDONALD

Fair-Haired Boy of the communications business at the moment is obviously television. The public is going for it in a great big way, and this interest is quickly reflected in engineering circles. Papers on the subject are reaching the editorial offices of ELECTRONICS in increasing numbers. Three appear in this issue (pages 72, 80 and 110) and many more are in process.

We Hear that an a-c/d-c television receiver is about to hit the market for about $150.

Television Receivers shipped by RMA-member companies in 1947 totalled 162,181. Here's where they went, by States:

New York	61,245
New Jersey	27,000
Pennsylvania	19,389
Illinois	13,727
California	7,898
Ohio	4,991
Michigan	4,887
District of Columbia	4,782
Missouri	4,090
Maryland	3,723
Connecticut	3,303
Wisconsin	2,315
Massachusetts	1,403
Minnesota	400
Virginia	399
Indiana	326
Delaware	174
Florida	41
New Mexico	21
Tennessee	15
Rhode Island	3
Texas	3
Unidentified	2,046

Power Companies in some cities are in a minor dither about television. Somebody has been spreading the misinformation that receivers won't work if the line voltage varies more than 3 percent from the nominal 115. Actually, most sets are ok from about 105 to 125 volts, which is better than 8 percent tolerance.

Rapid fluctuation of line voltage is more serious in connection with video images than the line voltage itself, partly because television receiver circuits are more critical than radio receiver circuits but largely because the eye is a more demanding organ than the ear. This has led a number of set manufacturers recently contacted to suggest that utilities commissions should tighten line voltage requirements from the present 5 percent tolerance (10 percent is actually permitted in many cases) to 2.5 percent or better.

The fact of the matter is that it would take three years or more for power companies to comply with such an order. Home appliances of all kinds are being sold in tremendous quantities and it is, we are told by good authority within our own McGraw-Hill shop, still impossible to buy enough pole transformers and other transmission gear to keep up with the rapidly increasing load. Utilities are trying hard, not only because of television, but also because fluorescent-light flicker is becoming serious.

It is this columnist's carefully considered opinion that makers of television receivers would do well to face the situation realistically and equip at least their better sets with voltage regulators and/or other automatic controls. Relief from the power companies will come slowly.

Indoor Tele Antennas (p 66, June) were exhibited by two manufacturers at the Parts Show. One was an extremely compact directional affair smaller than the average table lamp, and intended for use near the set. The other was an extremely novel metal-foil-covered cardboard antenna of the bi-conical type, designed to be set up like a folding advertising display and placed in an attic.

This, friends, is just the beginning.

Speaking Of Antennas, the Parts Show was once again forrested with trick f-m and television types. How, gentlemen, about adding parallel bars for the athletically inclined, and a swing for junior?

Not Many Test Instruments suitable for servicing television receivers were ready for exhibition at the recent Parts Show in Chicago. They were, booth at-

THE TREND . . . is definitely toward single-sideband operation. Advantages are obvious. Elimination of a continuously running carrier saves power and reduces interference. In fact, a signal is put on the air only when something is said.

HOWEVER . . . it does present some problems. To reproduce voice and music the equipment must handle high peaks of power even though the average power is very low. Unlike conventional AM service, where the modulation level must be held down so that the high peaks will not exceed available carrier, single-sideband modulation levels because of the absence of carrier are unrestricted by peaks and in general are limited only by the average power an r-f amplifier can produce.

TUBES . . . which can handle high peak powers in excess of normal rating are a natural for single-sideband work.

EIMAC TETRODES ARE THE ANSWER

REMEMBER . . . the universal use of Eimac tubes in radar? They were specified because of their ability to handle high peak power. Now, this ability enables them to take the lesser requirements of single-sideband service in stride. Eimac tetrodes handle high peaks because of their inherent ability to take momentary overloads, their reserve supply of emission, and freedom from internal insulators.

IT IS FAR EASIER . . . to produce a single-sideband signal at a low power level. Here again Eimac tetrodes fill the bill. Because of their high power-gain, this valuable low-power signal can be built up from the modulator to high power in a single amplifier stage.

IN ADDITION . . . the single-sideband driver must "see" a constant load resistance, and Eimac tetrodes with their low driving-power requirement mean a minimum of swamping action. It is even possible to run up the screen voltage until no grid current is drawn and no changing load is presented to the driver.

DATA AVAILABLE

PICTURED . . . above is the popular 4-65A tetrode. A new complete data sheet on it has been prepared. You will find SSSC ratings and suggestions in it . . . write today. Other Eimac tetrodes suited to SSSC application include 4X150A, 4-125A, 4-250A, 4-400A and the 4-1000A.

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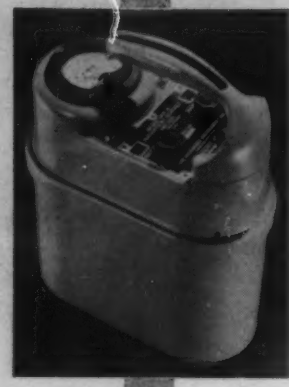
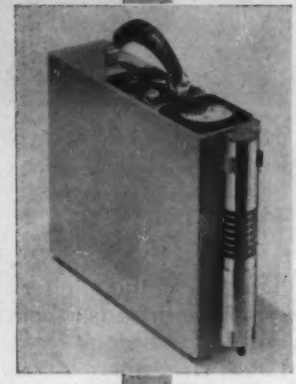


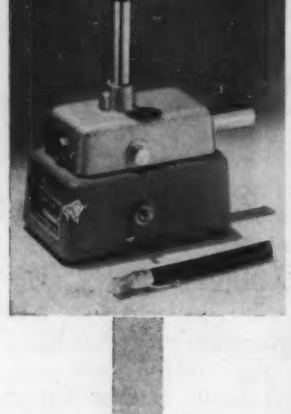
Gamma Radiation Survey Meter Model 247A

A compact portable instrument designed to cover four ranges of gamma radiation intensities, 2.5—25—2500 milliroentgens (1/1000 r) per hour. The most sensitiye range approximates that of a Geiger instrument and is inherently more stable. The ionization chamber and meter are hermetically sealed, and the case is watertight. Die castings have been used wherever possible for unusual rugged construction.



Beta and Gamma Survey Meter Model 263A

A portable Geiger-Mueller Counter for extreme sensitivity, capable of detecting individual ionizing particles. The instrument has three full scale ranges of 20.0—2.0—0.2 milliroentgens per hour measured with gamma radiation from radium.



Victoreen Minometer Model 287

The Minometer provides a prescription for computing daily, the amount of radiation exposure. It consists of a small compact string electrometer and an ionization chamber designed in the shape of a fountain pen to be carried conveniently in a coat pocket. The chamber value is 0.2 r full scale when checked against the calibrated scale in the electrometer.

For twenty years our exclusive business has been the development and design of instruments and components used in the measurement of gamma and x-radiation. We welcome your inquiries on any phase of radiation measurement.

Dept. A.

THE VICTOREEN INSTRUMENT CO.
5806 HOUGH AVENUE
CLEVELAND 3, OHIO

tendants said, "not quite ready."

Prediction: There'll be a healthy demand for such instruments soon, and the manufacturer that gets there "fustest with the mostest" will do very well indeed.

Farmers' Cooperative installation of five f-m stations in the vicinity of Ithaca, New York may start a trend and swell rural business. At last report the co-op was dickering with several manufacturers for 30,000 receivers.

Big Four items in the field of industrial electronics at the present writing appear to be, in this order, (1) high-frequency heating, (2) resistance welding control, (3) power rectification and, (4) motor control.

Pocket Screamer carried by people dabbling in radioactive materials consists essentially of an ion chamber, a low-leakage capacitor that is charged each morning, and a buzzer. When things get too hot to be healthy the capacitor lets go through the chamber and the buzzer buzzes.

The market for gizmos of this kind appears to be infinite.

Packaging of electronic equipment leaves much to be desired. Our products are particularly vulnerable to the idiosyncrasies of carriers and we get quite a lot of mail on the subject, most of it unprintable. A number of manufacturers are giving special attention to the problem, some with and some without outside aid. A lot more ought to devote time to it.

Radio-Teletype receiving unit developed by one of our readers appears to be extremely compact, inexpensive, and easy for nontechnical users in out-of-the-way places to keep running. Someone with a genuine need for such a unit and the facilities for trying it out is needed. *Business Briefs* will be glad to pass along correspondence.

Drive A Car? If so, you can handle the new wire and tape recorders ok. Several of them have a control for running the machine

forward and backward, erasing and etc., that for all the world resembles a gear-shift lever.

No license required.

Taxi Dispatching by radio is becoming so essential, particularly where competitive systems have snapped up all available channels, that some fleet owners are tempted to bootleg. FCC has already had to crack down on at least one illegal station. It won't be the last.

Dry Battery Sales are up this Summer, two of the biggest producers tell us. It seems like everyone and his brother has bought a portable radio.

Money To Burn is the only possible lead for this item. It seems that an eastern bank put some old and rare greenbacks in the window to stimulate business and slapped a mineral-oil filled television magnifier in front of it. Out came the sun next morning and set the stuff on fire.

Recently Published Figures (p 68, May) concerning the number of licensed amateur radio operators employed by manufacturers in our field stimulated several readers to conduct their own local surveys.

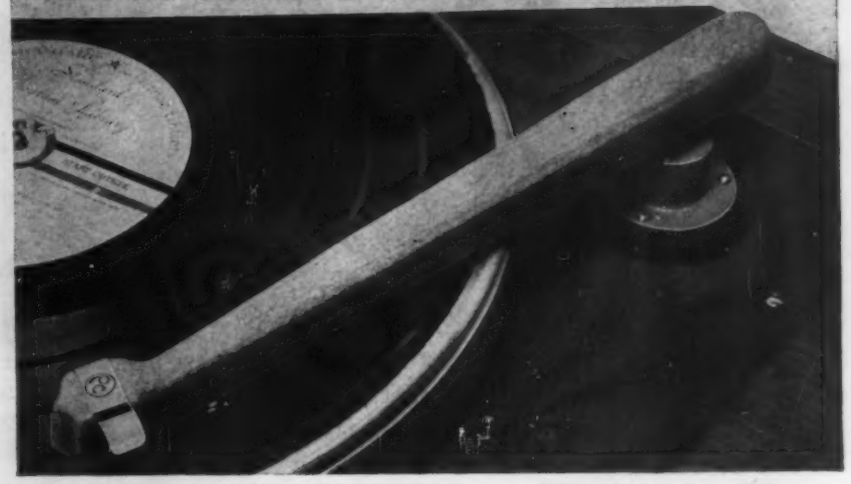
G. H. Floyd (W2RYT) says that he knows there are at least 200 hams working for G-E and suspects there might be twice that number. Airborne Instrument's Irwin Nye says his company employs 15. Lenkurt Electric has 6.

Practical Jokers are everywhere. In April we mentioned the fact that one of our draftsmen had made a mistake in connection with a circuit diagram of an electronic organ and lettered in the words "soft-shell crab" instead of "soft-swell tab." We went on to say that the error had been caught.

Several readers have since written in to tell us that the error actually appeared on page 118 of the May issue and we blush to report that they are quite right. It seems that one of the editors deliberately let it go through to give the readers a laugh.

P.S. He won't do it again.

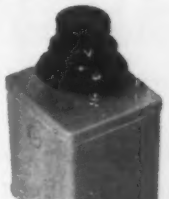
PICKERING REPRODUCERS



THE PICKERING MODEL 161M PICKUP incorporates all of the requirements for the finest possible reproduction of lateral records and transcriptions. It is extremely rugged and absolutely stable, ensuring long trouble-free service with minimum record wear. TECHNICAL SPECIFICATIONS include: Perfectly polished diamond stylus with .0025" radius; other radii available on special order at no extra cost ★★ Correctly offset head gives negligible tracking error ★★ Extremely rugged, may be scraped across records or dropped from full height without damage to pickup ★★ Tracking pressure adjusted at factory to 14-18 grams ★★ No measurable effect of temperature, humidity or age ★★ Equalized output level—60 dbm ★★ Frequency response flat within 1 db from 30 to 15,000 cycles per second ★★ Back-tracking will not affect either pickup or record ★★ Convenient finger grip permits rapid accurate cueing ★★ Optimum combination of counterweight and spring permits excellent performance on warped records ★★ Convenient to mount, occupies least space of any transcription reproducer ★★ No measurable intermodulation or harmonic distortion ★★ Adaptable for turntables from 1" to 2½" high ★★ UNCONDITIONALLY GUARANTEED.

THE PICKERING Model 163A EQUALIZER

positions
1. Flat high frequency response to over 15,000 cycles per second. Low frequency rise to give full compensation from 500 to 40 cycles.
2. Flat high frequency response. Low frequency response approximately 5 db below position 1.
3. For NAB or Orthacoustic transcriptions.
4. Low frequencies same as position 2. High frequencies sharply attenuated to reduce surface noise. Attenuation starts at 4000 cycles.
5. Low frequencies same as position 1. High frequencies same as position 4.



MADE to a tolerance of ± 1 db, provides five different lateral characteristics to equalize properly all types of records and transcriptions. It is designed for use with 250 to 600 ohm input circuits at a level of –60 dbm. Hum pickup is less than –120 dbm. The model 161M PICKERING PICKUP with a 163A EQUALIZER is so free from distortion of all kinds that it may be used as a standard for measurement.

THE PICKERING Model 125H EQUALIZER-AMPLIFIER for use with model 120M PICKERING CARTRIDGE REPRODUCER—it compensates for average recording characteristic, raises output voltage to as high as obtainable from crystal pickups, operates from the power supply of amplifier or radio set, saving cost of separate power supply, very simple to install.

THE PICKERING Model 120M CARTRIDGE REPRODUCER

A compact version of the PICKERING PICKUP for high quality reproduction, it fits into any arm which will accommodate a standard cartridge and affords the cleanest and smoothest response ever achieved. Its Frequency Response is ± 2 db, 40-10,000 cps . . . its Waveform Distortion is 1 percent maximum . . . its Output Level is 70 millivolts ± 2 db . . . its Tracking Pressure is 15 grams maximum at 40 and 10,000 cps. NO OTHER PICKUP CAN MATCH THE PERFORMANCE OF THE PICKERING MODEL 120M

Pickering & Company, Inc.

Oceanside, Long Island, N. Y.

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Which Properties Do You Need Most in Electrical Contacts?

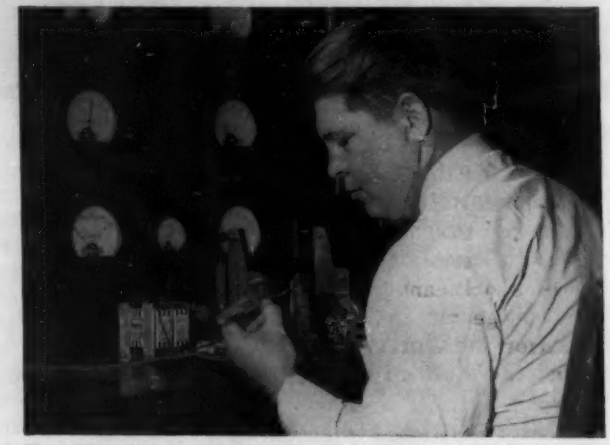
IN theory, the perfect contact material should combine non-sticking properties, low contact resistance, high thermal and electrical conductivity and resistance to electrical erosion with high strength and hardness. In actual practice (because operating conditions differ widely) only two or more of these properties usually predominate.

How does Mallory produce materials in which the correct properties for a specific job exist? You can be sure it isn't done by guesswork. Although Mallory has designed more than 5000 different contacts—has had 20 years of experience in metallurgy generally—it believes in rigid control. This control is accomplished by a series of spectrographic, chemical, electrical and microscopic tests such as you see at the right. They reveal the truth about chemical composition, grain structure, physical properties.

MALLORY STANDARDIZED CONTACTS

Yes, you're sure when you order Mallory contacts. Furthermore, you get the benefit of Mallory design experience, its manufacturing facilities for producing every kind of contact including contact assemblies. What's more, Mallory has developed eight basic contact designs that meet thousands of typical applications—save time and money involved in designing "specials." Send for the Mallory Contact Catalog.

This Mallory spectrograph determines the purity and composition of metals and alloys.



Here Mallory learns what happens in the electrical circuit when contacts are opened and closed.

With this unit, Mallory technicians measure contact resistance, temperature rise, and rate of wear.

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MALLORY ELECTRICAL CONTACTS & CONTACT ASSEMBLIES

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

CROSS TALK

▶**STAMPEDE** . . . An item in a recent issue of Martin Codel's excellent weekly television newsletter has us stopped dead in our tracks. The subject was the current shortage of channels for television and the shock came from two proposed solutions to the shortage which, it was rumored, were being given serious consideration in unnamed quarters of the industry. The first solution proposed the immediate use of channels in the 500-to-900-mc region now reserved for experimental development of television, including color systems. The second proposal was to reduce the width of the standard channel to something less than 6 mc, to allow more channels to be squeezed into the available space between 54 and 216 mc.

Both proposals, brother, are bad. Consider first the 500-to-900-mc space. We didn't know how to use this space for color television a year ago and it was on this basis, primarily, that the FCC turned down the color proposal and gave the green light to black-and-white. We still don't know how to use it. Eventually many of the missing answers will be forthcoming and then the space may prove useful for extending the present service. But any immediate shift to the uhf bands would bring many more problems than it would solve.

Reduction of the channel width is a bad idea now and it will stay that way indefinitely. Six megacycles is narrow enough for television, just as 10 kc is narrow enough for standard broadcasting. The 10-kc figure was a bad guess in 1925; it prevented high-fidelity broadcasting for 20 years. Only now is the f-m system redeeming the mistake. We can count on no such redemption for television, even in 1970.

We think the stampede for channels requires careful evaluation. Granted there aren't enough channels for all those who would like to enter the television broadcasting business. Granted the entrepreneurs are influential and can bring great pressure to bear on Congress and the FCC. But FCC decisions are hinged on the convenience and necessity of the *public*, not the broadcasters. And there is no great clamor, at present, from the public for additional television service. If J. Q. Public wants television service he must, first and last, live in an area sufficiently populous and prosperous to support the service. If he lives in such an area he can have a choice of seven programs. If fewer programs are available it is not due to lack of channels. It is because the level of trade in that area will not support the heavy expense of a seven-choice service. In many areas the seven available stations will not be in the same city, but by judicious use of directional antennas they will be available to all who want to tune to them. Otherwise there is no shortage of channels in that area.

We are, in short, up against the problem that has bedeviled standard broadcasting these past ten years. Shall we let down the bars on allocation standards to allow more broadcasters to enter the business? Within limits this is sound policy because it enhances competition. But the limits are reached when the quality of service is degraded to such a point that the public loses interest. Then everybody loses.

The FCC, facing up to the problem, has called a hearing on this subject for September. Certainly the pressure for additional channels, so long as it resides so largely in the broadcasting camp and so little in the body politic, must be resisted until the technical implications of a new allocations policy are thoroughly explored.

▶**ACRONYM** . . . The cockles of our heart warm to the new American College Dictionary published by Random House. One of the new words included is *acronym*, defined as "a word formed from the initial letters of other words, as . . . loran (from long range navigation)". We can't imagine a nicer example. We are happy that such recognition is given of the important place of acronyms in electronics (radar, shoran, sofar, sonar and so on). The new dictionary has many accurate definitions of technical terms in our field, thanks to contributions of W. L. Everitt, K. S. Johnson and others. We recommend it.

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Design Factors for INTERCARRIER

By STUART W. SEELEY

Director
Industry Service Laboratory
Radio Corporation of America
New York, N. Y.

THE intercarrier system of television sound reception, as previously described in these pages[1], amplifies the picture and sound signals together in the picture i-f amplifier. At the output of the picture second detector a beat note between the two signals appears. This beat is in effect a 4.5-mc intermediate frequency, frequency-modulated in accordance with the sound signal and amplitude-modulated (to some extent) in accordance with the picture signal. This intercarrier beat is passed through a frequency-modulation detector which is not sensitive to amplitude modulation. The sound modulation is thus separated from the picture and may be amplified and applied to the loudspeaker, as shown in Fig. 1.

When this system was first proposed the principal advantage appeared to be economy. The picture i-f amplifiers and video amplifiers do double duty in amplifying the sound signal, so a separate sound i-f amplifier is not necessary. Thereafter it became clear that the economic argument is by no means the most important one. There are many pros and cons rooted in the technical performance of the system which outweigh the cost factor.

Technical Advantages of Intercarrier System

The principal technical advantage of the intercarrier system is the fact that it is immune to the idiosyncrasies of the local oscillator of the receiver. Frequency modulation of the local oscillator due to hum and microphonics, as well as frequency drift, affect both sound and picture i-f signals substantially identically, so the 4.5-mc difference frequency remains unaffected. In a conventional receiver (using a separate i-f amplifier for sound, as shown in Fig. 2) these defects of the local oscillator produce an average effect four times as bad at the highest television channel (216 mc) as in the f-m band (108 mc) at full modulation. With television systen deviation (one third f-m sound broadcast deviation) the effect is emphasized by an additional factor of three.

Secondly, the tuning of an intercarrier receiver is considerably simplified by the fact that the sound is always correctly tuned in when switching from one station to another. Fine tuning of the local oscillator is not necessary to tune in the sound. Moreover, the intercarrier system is somewhat freer from the effects of interference.

Technical advantages related to economy of design include not only the dual use of the i-f and video amplifiers but also the fact that the local oscillator design can be somewhat less expensive. In fact, hum frequency modulation and drift may have values several times those allowable in a conventional receiver. In inexpensive receivers, the i-f passband may be made symmetrical, and this will allow the local oscillator to operate on the high side for the lower channels, and on the low side for the upper channels.

Disadvantages

The primary disadvantage of the intercarrier system is the fact that the 4.5-mc beat signal depends on the presence and character of the picture carrier. Any unusual effect present in the picture carrier can have a corrollary effect on the sound output and this possibility exists whether the effect arises in the transmitter or the receiver, or is caused by interference from other sources.

One of the most important examples occurs whenever the picture modulation is so heavy that the picture carrier disappears completely during the transmission of a peak white portion of the picture. When the picture carrier is thus modulated to zero, the 4.5-mc beat note disappears for that instant and no sound signal is received. This

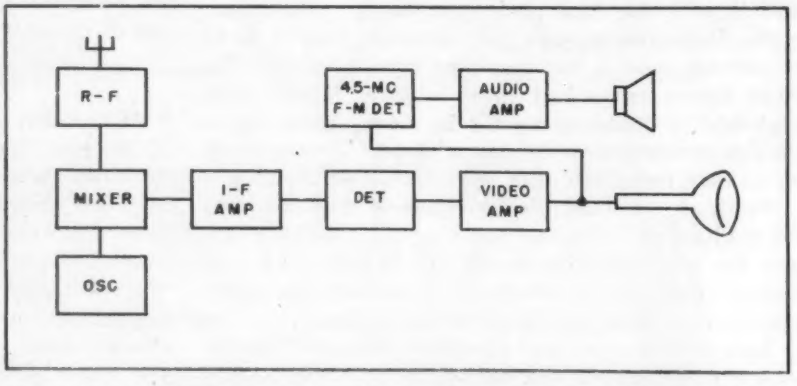

FIG. 1—Typical intercarrier receiver. The i-f, video detector and video amplifiers do double duty, handling picture and sound signals simultaneously

TELEVISION SOUND

Large scale production of television receivers employing intercarrier sound has focussed attention on the advantages and disadvantages of the system. This review emphasizes problems facing transmitter and receiver designers

causes severe interference in the sound signal, in the form of a 60-cycle buzz or 15,750-cycle hiss, since the loss of sound signal is repeated at the field and line-scanning rates. This possibility requires that the percentage modulation at the transmitter be monitored carefully, so that the minimum picture modulation shall not fall below approximately 10 percent of the peak value. There is at present no regulation requiring such monitoring. Before the intercarrier system can be employed with assurance of high-quality transmission at all times, such a regulation will be required.

A second effect, of nearly equal importance, is that caused by any phase or frequency modulation of the picture carrier. This carrier is nominally modulated in amplitude only, but actually may be modulated in phase or frequency to a slight degree. Such variations in picture phase or frequency are imposed on the 4.5-mc beat note and cannot be separated from the frequency modulation of the sound signal. The result is, again, a 60-cycle or 15,750-cycle note of magnitude depending on the extent to which the picture carrier is phase or frequency modulated. It should be noted that the frequency-modulation detector which converts the 4.5-mc beat signal to audio is in effect a phase detector, for all frequencies above about 2.5 kc, when 75 μsec de-emphasis is used.

There are many possible causes of phase or frequency modulation of the transmitted picture carrier. One is variation in the transit time (which produces a change in phase angle of the carrier) in any modulated stage of the transmitter. However, this is of negligible magnitude compared with the effects of unsymmetrical tuning or incomplete neutralization. In a 5-kw transmitter, even one-half watt of constant fed-through power can produce as much as a 6-degree total phase shift when the modulation level is at 10 percent of peak carrier. This amount of feed-through can occur even in a properly neutralized stage, and the effect can be identified in the output of an intercarrier sound receiver. For example, 4 degrees peak shift at 15 kc will produce interference only 28 db below average (30 percent) modulation without deemphasis.

Deemphasis improves the situa-

GOOD NEWS

In *Crosstalk* last month, we pointed to the growing use of intercarrier receivers, and quoted the misgivings of video transmitter designers, who feared poor reception from high-band stations. Since that item was written, Mr. Seeley and his colleagues have perfected a measuring technique and have applied it to a wide variety of stations, with the startling results reported here. Early opinion had it that even half a degree of transmitter peak phase shift (approximately one degree total) would produce noticeable interference. Before the tests, Mr. Seeley himself quoted 4 to 6 degrees total shift as the probable tolerable limit. But stations having 15 to 20 degrees total phase variation, measured by the new method, were found to produce excellent sound quality on properly designed intercarrier receivers. As a result of these tests industry opinion is undergoing a rapid shift on this subject. It appears that the necessary industry-FCC action to permit proper use of the intercarrier system will shortly be taken.—The Editors

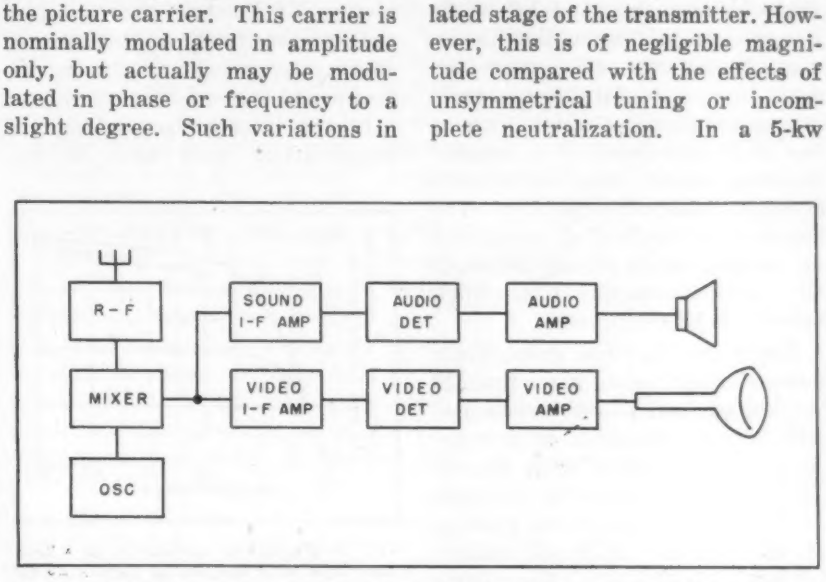

FIG. 2—Typical conventional television receiver. This type of receiver is more susceptible to faults in the local oscillator than is the intercarrier type

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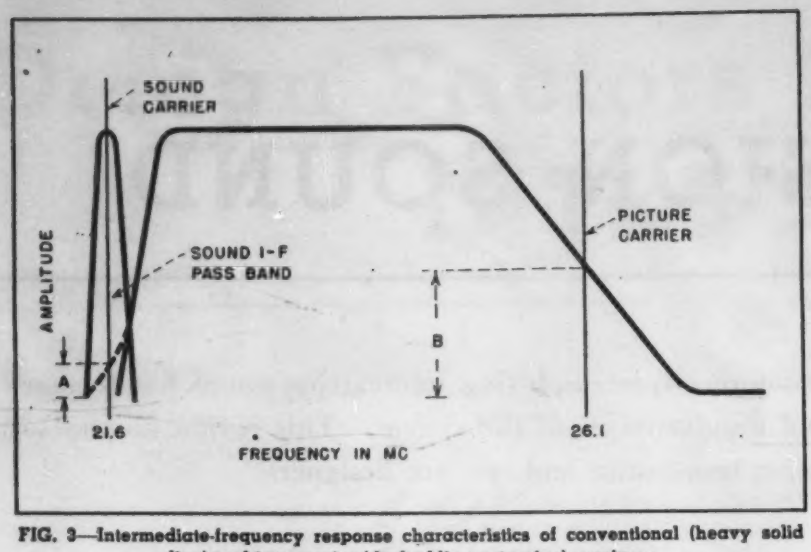

FIG. 3—Intermediate-frequency response characteristics of conventional (heavy solid line) and intercarrier (dashed-line extension) receivers

tion and the effect is less prominent at lower audio frequencies. But, even with deemphasis, over the range of audio frequencies from 3,750 to 15,000 cps, a 4-degree phase shift will produce interference from 48 to 45 db below average modulation. This would not be considered sufficient for a high-quality sound system. But recent tests have shown that much more than 4 degrees of phase shift can be present without adverse effects on sound quality. At least two additional factors tend to lessen the interference:

1 Since the transmitter's residual frequency modulation is caused by a phase-variation process the corresponding frequency modulation decreases 6 db per octave as the audible frequency of the video modulation causing the phase variation is decreased. Other types of interference (which the FCC specifies must be below a -60 db level in a high-quality aural broadcasting system) have more uniform distribution in the audible spectrum.

2 The second point concerns the distribution of audible energy in a composite video signal. If we examine the amplitude-modulation components between zero and 20,000 cycles derived from a picture-modulated transmitter we find one very strong component at the 60-cycle field frequency and another at the 15,750-cycle line frequency. What occurs in between depends partly upon the number, position and intensity of any horizontal lines in the picture. However, harmonics of 60 cycles up to a rather high order, but with rapidly decreasing level with frequency, are caused by the square-wave nature of the vertical synchronizing and blanking portions of the signal.

Obviously 60 cycles is too low to convert phase modulation to frequency modulation in any important degree, being 48 db below the 15,000-cycle conversion. Also, 15,750 cycles is outside the audible range and can be removed in the receiver if necessary. Therefore, it is apparent that we need only be concerned with audible video components lying considerably above the field frequency and below the line frequency. Observation has indicated that this entire range seldom, if ever, contains components stronger than those which occur at the start and finish of a vertical blanking pedestal transmitted with a white background picture. The latter cause spikes of frequency modulation which plainly delineate the vertical-blanking time when viewed on an oscilloscope.

The energy in those spikes from a transmitter having more than 20 degrees of total phase variation is still next to inaudible in a wide-range sound system even though the spikes are frequently as much as 15 db above the meter reading of the average incidental audible frequency modulation. Experience thus far has indicated that satisfactory performance, at least in receivers which do not offer the full range of audio fidelity, can be obtained without difficulty on all presently operating stations provided they do not overmodulate the picture carrier.

Another difficulty with the intercarrier system is the fact that any drift of the frequency-modulation detector from the 4.5-mc center frequency will introduce distortion, and there is no way to correct this condition except by adjustment of the detector itself. Similar distortion in a conventional receiver can be corrected by adjustment of the fine tuning control.

A final difficulty is that which occurs if the sound carrier, as presented to the second detector, exceeds a certain level relative to the picture carrier. If this occurs, severe distortion of the sound output and picture quality may occur, including possible reversal of the image tones ("negative" in the photographic sense). This effect may be controlled by care in the design of the i-f pass-band curve, as described below.

Design Considerations

The first question in the design of an intercarrier receiver is the method of setting the relative level of the sound and picture carriers at the input to the second (video) detector. In the conventional receiver the pass-bands of the i-f systems are as shown in Fig. 3. The picture i-f amplifier has substantially no sensitivity (on the average 45-db attenuation) at the associated sound channel frequency.

In the intercarrier system, the sound-carrier pass band is dis-

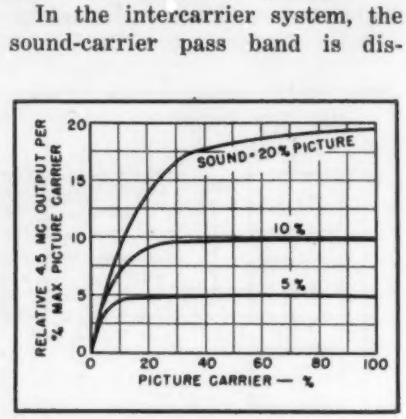

FIG. 4—Amplitude modulation of 4.5-mc beat note as a function of picture modulation, for various amplitudes of sound signal relative to picture signal

pensed with and the picture i-f pass band is extended slightly to increase slightly the gain at the sound carrier. This is shown in Fig. 3 as a dashed-line extension of the picture pass-band curve. The percentage response of this extended curve at the sound-carrier frequency is indicated by the dimension *A*. This dimension should never be greater than 10 percent of the carrier level (dimension *B*) in linear units. This is on the assumption that the sound and picture carriers are of equal strength as received from the transmitter. But variations in relative signal strength of as much as 10 db, arising from differential attenuation and wave interference effects dependent on the receiver location, are apt to occur so a more conservative figure for dimension *A* is 3 percent of *B*.

One basis for the 10 percent maximum figure may be seen from Fig. 4, which shows the relative output of a linear detector when f-m sound and a-m picture are fed to it simultaneously. So long as the rms level of the sound signal is 5 percent or less of the maximum rms picture signal, as in the lowest curve, the 4.5-mc beat note amplitude remains substantially constant as the level of the picture carrier (abscissas) varies under modulation from 15 to 100 percent of the peak value.

If the sound level is 10 percent of the maximum picture level as in the middle curve, the output remains flat from 25 to 100 percent modulation. At higher relative sound levels (top curve) the output would contain substantial amplitude modulation in accordance with the picture modulation. Also the picture quality would be badly degraded as previously stated.

Much of the residual amplitude modulation may be removed by the use of a limiter or by the use of a balanced discriminator or ratio detector. However, if the residual amplitude variation is too severe an excessive burden is placed on the f-m detector. This is the basis of the previous statement that the amplitude modulation level of the picture transmitter should not normally be allowed to fall below 10 percent of the peak synchronizing level.

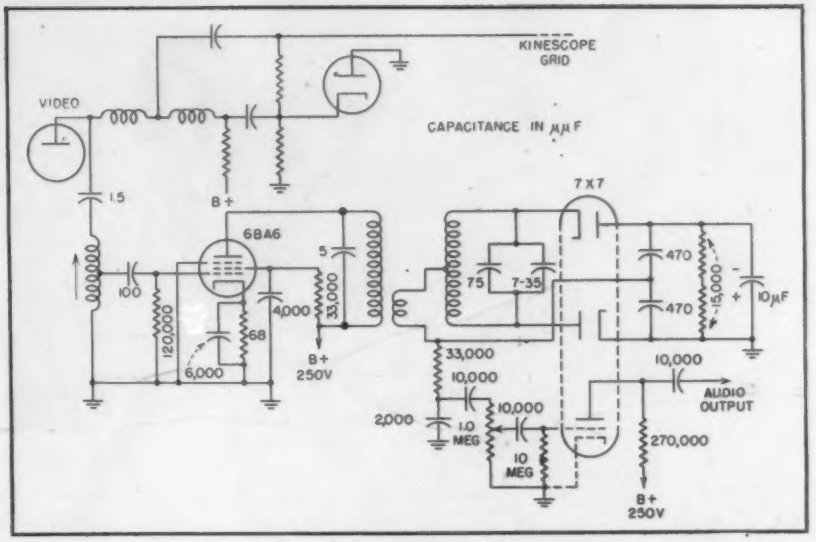

FIG. 5—Typical intercarrier sound circuit using a limiting amplifier and ratio detector for demodulation

The attenuation of the sound signal, to 3 percent or less of the picture carrier, implies a corresponding increase in amplification (relative to that provided in a separate sound i-f amplifier) to bring the sound signal up to the level required for detection and audio amplification. A portion of this extra amplification is provided by the passage of the sound signal through the video amplifiers. Normal peak video level at this point is about 30 volts, so the sound level usually does not exceed one volt. Conservative design suggests that this level be increased before the sound signal is applied to the f-m detector.

An auxiliary amplifier for this purpose also serves an important function in keeping the volume level substantially constant as the picture gain control is varied. Such constancy of gain is also useful in overcoming the tendency of the sound level to increase as the picture is detuned. Otherwise, if fine tuning is provided, the lay user might try to tune for loudest sound, which would produce a poor picture.

Care should be taken to avoid overload in any stage which could remove the picture signal (and its concomitant 4.5-mc sound i-f signal) even momentarily. The diode second (video) detector should be as linear as possible, and the ratio of a-c impedance to d-c resistance of the second detector load should be as near unity as possible. Finally the tuned circuits in the f-m detector should be designed to maintain proper adjustment since drift in these components cannot be corrected by the user. If these precautions are followed, and if the restrictions on transmitter operation previously mentioned are observed, the intercarrier system can give excellent performance.

A typical example following closely the design criteria mentioned is shown in Fig. 5. The 4.5-mc beat note is taken directly from the last video amplifier plate. The series resonant impedance at this point removes any remaining 4.5-mc beat from the picture tube grid. The first tube (6BA6) serves as a volume-leveling amplifier, or limiter. It is so designed that the tube operates under plate voltage overload when a small signal is applied to its grid. Hence the output does not change when substantially stronger signals are applied. The output of this amplifier is passed to a conventional ratio detector which develops the audio output. The output is about 2.5 volts rms for 25-kc deviation, so a voltage amplifier must precede the audio output stage. In this example, this is provided by a triode in the same envelope with the double diodes, in a 7X7 tube.

Reference

(1) R. B. Dome, Carrier Difference Reception of Television Sound, p 102, Electronics Jan, 1947.

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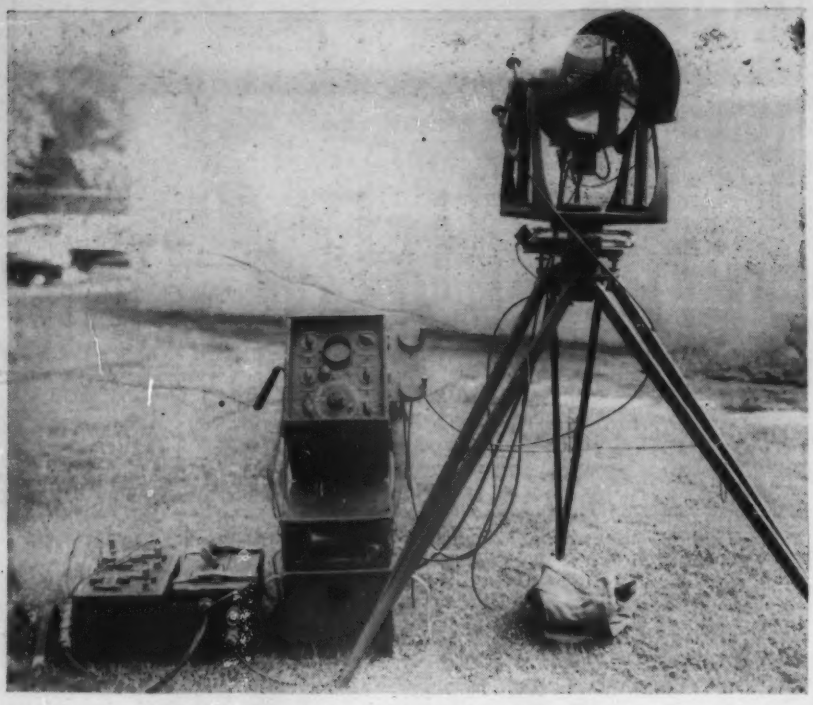

Optical radar equipment set up at base site ready for use

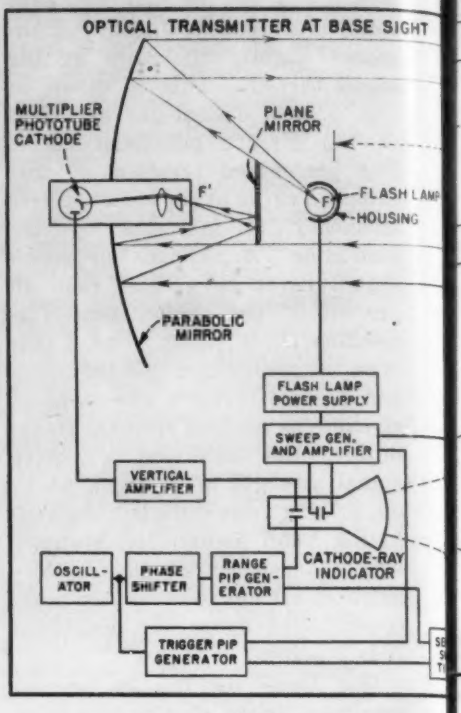

FIG. 1—Block diagram shows

Surveying With Pulsed-Light Radar

Adaptation of radar techniques to terrain surveys, wherein pulses of light from a flashlamp at one site are reflected back to a multiplier phototube by a mirror at the other site. Distance is read directly on dials after c-r tube pips are aligned

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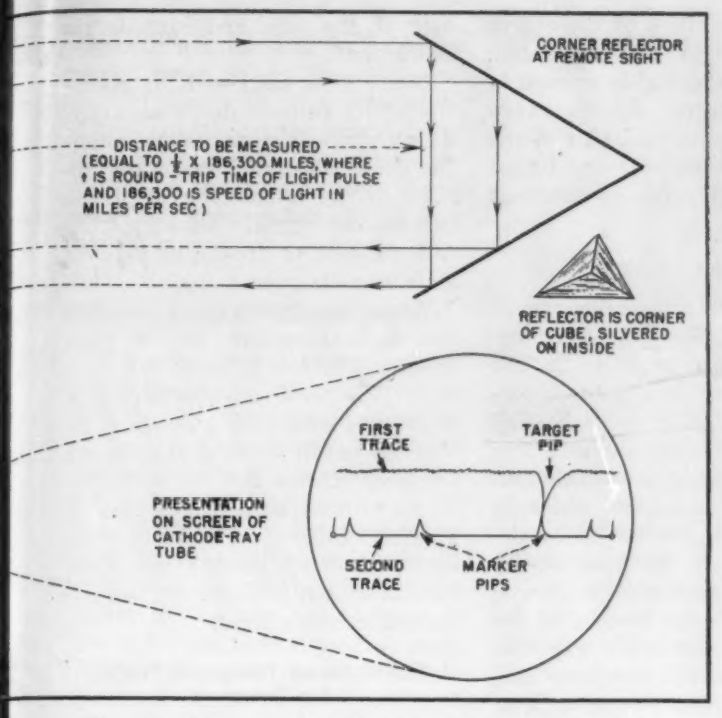
Chicago, Illinois

THE optical-electronic instrument described here is capable of making a survey of terrain when conventional survey methods would be too slow or when long traverses over inaccessible terrain are needed. The choice of light instead of microwave radar signals was made because of the improved resolution and because reflections of microwave signals from objects other than the target would limit the usefulness of the equipment.

Distance or range is determined by measuring the transit time of pulses of light traveling to and from a retrodirective reflector placed at a point whose relative position is to be found. Angles are determined by adjusting the position of the optical transmitter to produce a maximum return pip on a cathode-ray tube. While the accuracy of the survey which can be obtained with this instrument is not as good as that which can be achieved by conventional surveying methods, it does compare favorably with the accuracy of a third-class survey.

The over-all method of operation of the system is shown in Fig. 1. When the flashlamp in the optical transmitter breaks down, it triggers the sweep generator and causes a trace to appear on the cathode-ray tube. The light pulse transmitted by the lamp is returned from the distant reflector and falls on the cathode of the photomultiplier, causing a pip to appear on the trace. Upon returning to its normal state the sweep generator triggers the second sweep timer, which gates the range and trigger pip generators. These produce a second trace displaying range pips which can be matched with the target return pip by adjustment of the phase shifter.


CORNER REFLECTOR AT REMOTE SIGHT
DISTANCE TO BE MEASURED (EQUAL TO $\frac{1}{2}$ X 186,300 MILES, WHERE t IS ROUND-TRIP TIME OF LIGHT PULSE AND 186,300 IS SPEED OF LIGHT IN MILES PER SEC.)
REFLECTOR IS CORNER OF CUBE, SILVERED ON INSIDE
FIRST TRACE
TARGET PIP
PRESENTATION ON SCREEN OF CATHODE-RAY TUBE
SECOND TRACE
MARKER PIPS

how travel time of a flash of light is used in surveying

Front panel of main electronic unit

When the second trace is completed, the circuits return to their normal states and are ready to repeat the cycle when the lamp flashes again.

The instrument consists of four main units, called the optical head, the scope unit, the main power supply, and the converter unit.

The optical head is mounted on a tripod and contains the flashlamp and optical system necessary for transmitting the light from the lamp, receiving it from the distant reflector, and focusing it on the cathode of a photomultiplier. The output of the photomultiplier is amplified by a two-stage amplifier which is also part of the optical head and is contained, with the multiplier, in a chassis attached to the rear of the mirror housing. The optical head is mounted on bearings attached to graduated circles that permit its elevation and rotation to be determined within one minute of arc.

The output of the amplifier is fed through a delay line to the scope unit, where it is amplified by two additional stages of amplification to produce the vertical pip on the cathode-ray tube. The scope unit is mounted on top of the main power supply during operation and can be tilted for the convenience of an operator seated in front of it. This unit contains, in addition to two stages of vertical amplification and the cathode-ray tube, the sweep circuits and other circuits necessary for the precise determination of range.

The entire equipment is designed to operate from 110-volt, 60-cycle a-c power or from a 12-volt battery. When d-c operation is desired, a 12-volt d-c to 110-volt a-c rotary converter contained in the converter unit is used. This unit also contains a neon sign transformer and rectifier to operate the flashlamp. The flashing rate of the lamp is controlled by varying the voltage fed to the primary of the neon sign transformer by means of a Variac located in the main power supply. This unit supplies the plate and accelerating voltages to the tubes in the scope unit and in the optical head.

During operation the operator can turn the optical head by means of flexible shafts attached to cranks which fit on the scope unit. The electrical cables connecting the units during operation are stored in a compartment attached to the bottom of the scope unit when the units are packed for transportation. The sizes and weights of the units are such that they can be manborne.

The focal point of the parabolic mirror coincides with the center of the arc at point F′ (Fig. 1) so that an image of the arc is formed at infinity. The light returning from the target is focused on the pinhole or slit at point F′ and then passes through the center of the parabolic mirror to the cathode of the photomultiplier. A slit is used at point F′ for ease in finding the target when a search is being made for it; the pinhole is used for angular definition after the target has been found.

Ranging Method

The range accuracy requirements led to the adoption of a ranging scheme which involves the comparison of light transit time with the period of a crystal-controlled oscillator. An essential part of this scheme is a device which shifts the phase of the oscillator output to permit the matching of range pips to the target return pips. While no originality for this idea can be claimed here,[1] its application to an optical transmitter involved special problems in synchronization.

The process of pulsing a radio transmitter at a given instant is

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fairly straight-forward and precise, but some concern was felt about the feasibility and possibility of triggering a gas discharge lamp within a very small fraction of a microsecond of a desired time, especially in view of the size and weight restrictions on the equipment. Instead of initiating the flashes of the lamp in synchronism with the oscillator, it would have been fairly easy to have started and stopped an oscillator in synchronism with the flash-lamp, but this usually entails some sacrifice in oscillator stability as compared to that of a free-running crystal oscillator and also introduces transient errors in the phase shifter.

Double Trace

These problems were avoided by the use of circuits which cause two traces to appear on the scope for each flash of the lamp. The first trace starts when the lamp flashes, and displays the target return pip; the second trace starts about 0.01 second later and in synchronism with the oscillator. The second trace can be shifted vertically relative to the first one and displays a series of ranging pips which can be moved horizontally by means of the phase shifter until one of them matches the target return pip.

The appearance of the scope screen when pips are matched is also shown in Fig. 1. The frequency of the oscillator is such that the interval between successive ranging pips corresponds to a range interval of 500 yards. A course range switch permits the interval containing the target pip to be brought to the center of scope screen, where it is expanded to give greater matching accuracy. When pips are matched the range is the sum of the readings of the coarse range dial and the fine range dial. The coarse range dial is marked in steps of 500 yards; the fine range dial is attached to the shaft of the phase shifter and is graduated from 0 to 500 yards at intervals of 1 yard.

Sweep Circuits

The schematic circuit diagram of the sweep generator and sweep amplifier is shown in Fig. 2. The sweep generator is a cathode-coupled flip-flop circuit whose holding time is about 35 microseconds. The sweep amplifier is a cathode-coupled push-pull amplifier which is direct-coupled to the horizontal deflection plates of the cathode-ray tube. When capacitor C_1 is charged to a potential equal to that of the breakdown of the spark gap, the lamp discharges this capacitor and, in doing so, applies a positive pulse to the left grid of T_1. This causes the normally conducting right half of the tube to be cut off for a time which is determined mainly by C_2 and R_1.

When T_1 is triggered the potential difference across C_3 increases and causes the left grid of T_2 to become more positive. The change in potential across C_3 is considerably larger than that necessary to drive the left half of T_2 from cutoff to saturation, and consequently the cathode spot moves across the cathode-ray screen only during a portion of the time that C_3 is charging. The time at which the sweep starts is determined by the setting of the coarse range switch which adjusts the bias on the left grid of T_2. If this grid were returned directly to ground, it would always be biased considerably beyond cutoff by the current flowing through the right half of the tube and cathode resistor R_2.

When T_1 is triggered the potential of its cathode drops abruptly. This change in potential is amplified by a deblanking stage and applied to the intensity grid of the cathode-ray tube, allowing the cathode spot to appear as long as T_1 is in its triggered state.

When the target is being searched for, a range-search switch (not shown) is turned to the search position. This places another capacitor in parallel with C_3 and biases T_2 so that the sweep starts at the instant the lamp flashes and the spot continues to move across the screen at a fairly uniform rate during the entire 35 microseconds sweep time. In this switch position, the second trace does not appear.

Second Sweep Timer and Trigger Pip Generator

When T_1 (Fig. 2) returns to its normal state the potential of its cathode rises abruptly to about 50 volts and then drops rapidly to its normal potential of about 20 volts. This abrupt rise in potential is used to trigger the second sweep timer, shown in Fig. 3, which is a flip-flop circuit with a holding time of about 0.01 second. The output of the oscillator is sufficient to overload T_1, causing its output to approximate a square wave. This is differentiated so that the signal appearing at the grid of T_2 is a series of alternately positive and negative pulses. Tube T_2 is normally biased sufficiently to prevent any signal from appearing at its plate. However, when T_2 returns to its normal state its cathode potential rises abruptly, producing a pedestal voltage at the control grid of T_3 and allowing a pulse to trigger the

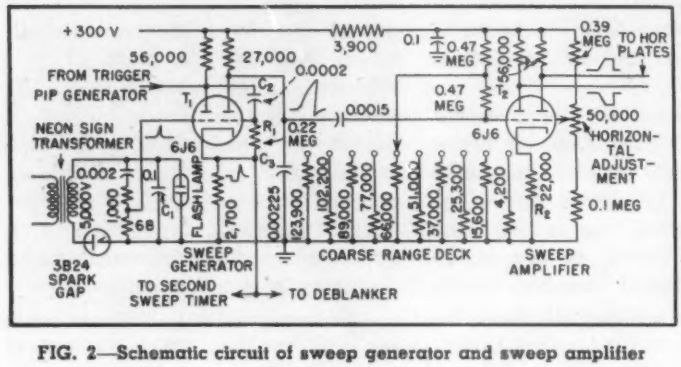

FIG. 2—Schematic circuit of sweep generator and sweep amplifier

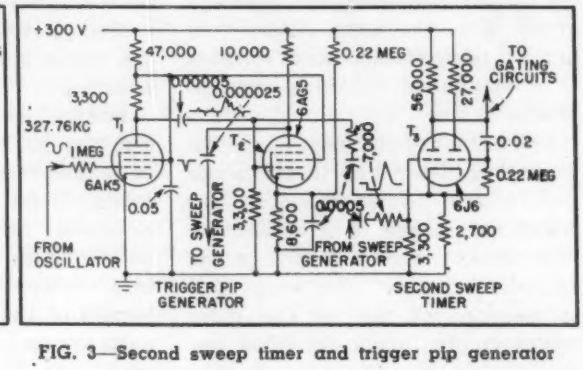

FIG. 3—Second sweep timer and trigger pip generator

sweep generator and initiate the second sweep. When the sweep generator returns to its normal state it does not trigger the second sweep timer again because the cathode potential of the second sweep timer does not drop sufficiently during the 35-microsecond second sweep interval.

Gating Circuits

When the second sweep timer is triggered at the completion of the first sweep, the drop in potential of its left plate is used to actuate gating circuits which shift the second trace vertically relative to the first and allow marker pips to appear on the second trace. These circuits also cut off the vertical amplifier during the second trace to prevent noise from appearing on it.

The schematic diagram of the gating circuits is shown in Fig. 4. The cathode-ray circuits are shown for clarity but only a portion of the range pip generator is shown because it is similar to the trigger pip generator except for an additional stage of amplification to compensate for the phase shifter attenuation.

The values of resistors R_1 and R_2 are chosen to apply a positive potential to the grid of T_2 when the second sweep timer is in its normal state. The cathode current of T_2 flows through the center-tapped potentiometer R_5 and produces a difference in potential between the vertical deflection plates of T_3 whose magnitude and sign depend on the position of the slider relative to the center tap and thus determine the position of the first trace relative to the second.

When the second sweep timer is triggered, T_2 is biased beyond cutoff. This releases some of the bias on T_1, allowing a signal consisting of a series of negative pulses to be applied to one of the vertical plates of T_3 and cutting off the plate current which flowed through R_5 during the first trace. Capacitor C_1 insures that T_2 remains cut off during the second trace.

Resistors R_3 and R_4 are chosen so that the final stage of the vertical amplifier is biased beyond cutoff during the second trace but is biased normally during the first. Capacitor C_2 insures that the vertical amplifier remains cut off during the second trace.

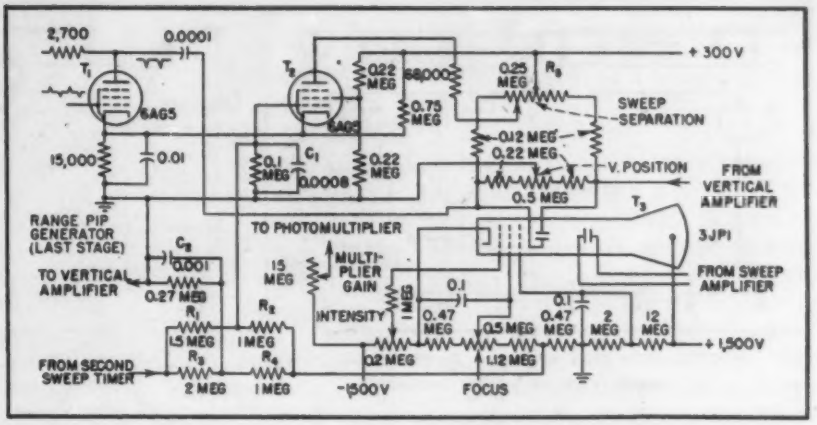

FIG. 4—Schematic diagram of gating circuits and cathode-ray tube

The schematic circuit diagram of the phase shifter and of the phase-splitting circuits which supply it is shown in Fig. 5. The phase shifter is a special capacitor[2] consisting of four quadrants that induce voltages in a common pickup plate which faces them. An eccentrically mounted circular Mycalex disk is mounted between the quadrants and the pickup plate so that the capacitance between each quadrant and the pickup plate varies as the disk is rotated. One mechanical degree of shaft rotation produces one electrical degree of phase change in the vector sum of the voltages induced in the pickup plate, provided the quadrants are supplied with voltages of equal amplitude but in phase quadrature. This situation will exist if the reactances of C_1 and C_2 (Fig. 5) are equal to the resistances of R_1 and R_2 at the oscillator frequency and if the network is balanced to ground. Capacitor C_3 helps provide a balance to ground by compensating for the interwinding capacitance between L_1 and L_2.

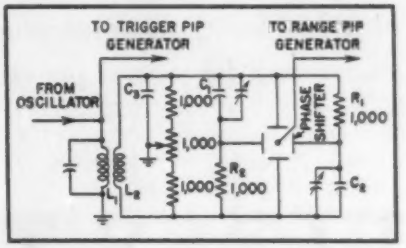

FIG. 5—Phase shifter and phase-splitting circuits

Vertical Amplifier

The vertical amplifier has a voltage gain of about 85 db and is shunt compensated to a top frequency of 2 mc. A delay line between the second and third stages serves as a flexible coupling between the optical head and the scope unit and delays the signals sufficiently to allow range readings to be made on very close targets. In fact, the zero adjustment of the phase shifter shaft is made by holding a reflector next to the framework of the optical head and in the light beam. This permits a ready determination of the zero correction in the field.

Acknowledgement

Acknowledgement is made to the U. S. Army Engineer Research and Development Laboratories under whose sponsorship and supervision the developments described were accomplished at the Armour Research Foundation; to the Radio Corporation of America who developed special photomultipliers, and to the General Electric Company and the Amglo Corporation for the development of flashlamps. Credit is also given to Bell Telephone Laboratories for their wartime work under NDRC contract resulting in basic developments in range measuring equipment utilizing the transit time of light pulses.

References

(1) A similar scheme was used in the AN/MPG-1 Radar, ELECTRONICS, p 140, March 1946.

(2) The theory of operation and a discussion of the errors of the phase shifting capacitor are given in the Dept. of Commerce, Office of Technical Services Reports No. PB 2810 and PB 3942. These capacitors are made by the P. J. Nilsen Company, Oak Park, Illinois.

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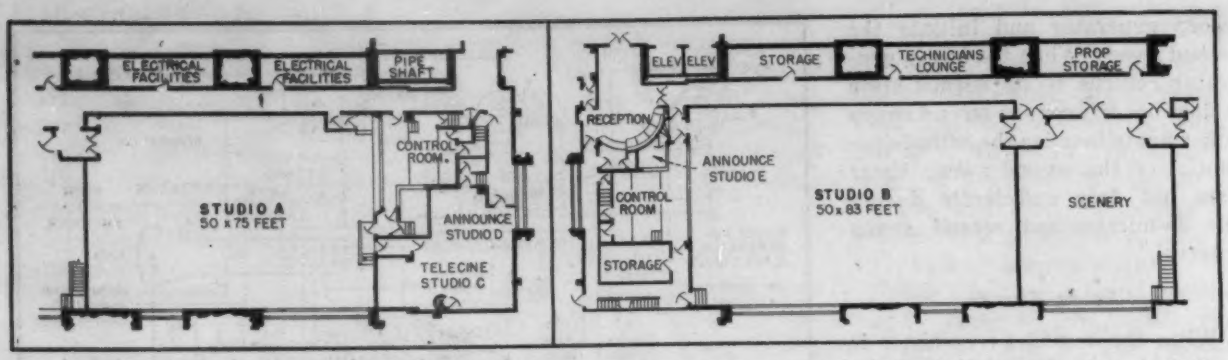

FIG. 1—Partial floor plan of Studio A, film-projection studio, control room and other facilities

FIG. 2—Simplified floor plan of Studio B, control, announce Studio E, scenery, other storage, and technician's lounge

Design criteria for video and audio facilities capable of meeting the requirements of complex television program production are discussed in relation to future expansion. Included will be special provisions for studio lighting, air conditioning, communications, and sound effects

WCBS-TV . . . New Grand

By A. B. CHAMBERLAIN
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New York, N. Y.

THE Columbia Broadcasting System now has under construction modern television studios at WCBS-TV, the New York key station of The Columbia Television Network. Over 700,000 cubic feet in the Grand Central Terminal Building are available for this large-scale operation. Adequate space, and thorough planning for operational flexibility and future expansion, are the twin keynotes of the project.

Closely associated with two large live-talent studios and their control rooms are a film scanning studio, master control, three announce studios; electrical, carpenter, and equipment shops, scenery painting space; rooms for dressing and makeup, film editing and splicing, viewing, staff lounges, key operating personnel offices, art and sound effects, studio lighting control, primary power switching and control, storage, reception, and other related facilities.

The equipment layout is designed to furnish a high degree of flexibility and will include ample facilities for handling previews, rehearsals, programming from studios, film and slides, as well as remote and network programs via coaxial cable or radio relay. The master control switching and distribution system for both audio and video is capable of handling any combination of twelve input circuits to six outgoing points. The switching system is a preset open-ended type which allows for convenient expansion or modification.

In general, facilities consist of:

(1) One large live-talent studio (Studio A) containing three cameras, seven or more microphones, portable video monitors and loudspeakers, talk-back loudspeakers, studio communication equipment, camera dollies, microphone booms, and other necessary components.

(2) A second large live-talent studio (Studio B) with two cameras and other facilities similar to those enumerated for Studio A.

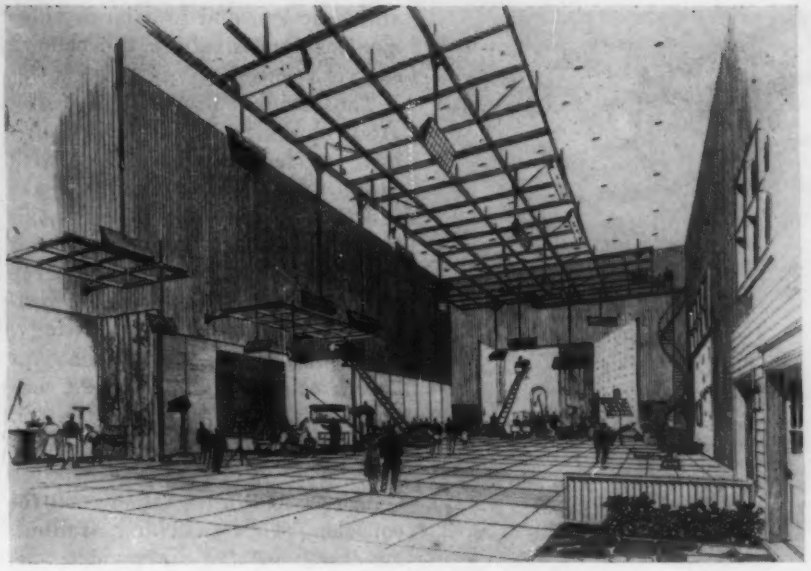
(3) A film projection room (Studio C) with four camera chains and eleven film and slide projectors.

(4) A combined master control and film control room where synchronized switching of all audio and video program material is effected as well as control of the four film camera chains. Provision is made for a flying spot scanner.

(5) Three announce studios (Studios D, E and F) equipped with microphones, in addition to audio and video monitoring equipment.

(6) Two sound effect rooms, a viewing room, and two studio lighting control rooms, all equipped with communication facilities, microphones, and audio and visual monitors.

Studios A and B and their associated control rooms are engineered for a total of four camera chains; Studio C, film scanning, is arranged to accommodate three more projectors and a fifth camera chain.



Artist's drawing of Studio B, as it will be seen from the control room

Central Studios

The audio and video pickup, control, switching and monitoring facilities are arranged in a more flexible manner than similar facilities in the past. They are also designed for maximum ease of operation and maintenance. It will be possible, for instance, to mix with the microphone and camera outputs of any studio, action originating from the film studio, from the other live-talent studio, or from local, remote, or network points. Such multichannel control can be exercised in either of the two studio control rooms or in master control, where the Studio C control consoles are located, as circumstances warrant.

The systems design of the audio and video facilities together with other related facilities such as primary power supply, studio lighting, air-conditioning, sound effects, clocks, and also the physical layout of the entire space, is based upon operating specifications representing the combined viewpoint of the General Engineering, Construction, Technical Operations, and TV Program Departments. This initial planning has resulted in an approved physical layout, a basic equipment systems design, procurement of technical and other facilities, and a work schedule covering the entire project.

When planning a new station, the need for developing operating specifications which take into account projected program production planning is extremely important. Without such consideration, the system engineering is likely to be inadequate, and may require many expensive modifications later. On the other hand, lacking such carefully established requirements, the system may become much larger than necessary, resulting in an unnecessarily large capital expenditure.

The Studios

Figure 1 shows the arrangement of Studio A which is 50 × 75 feet with a 26-foot ceiling. A potential ceiling height of 45 feet is available. The arrangement of this studio with its associated control room, announce Studio D, and film Studio C, are indicated. Although details are omitted, excellent traffic and visual contact are maintained between the studio, its control room, and announce Studio D. Other important facilities not shown here are the studio lighting control room located on a balcony over one side of the studio, and an arrangement in the center of the studio floor for the passage of camera, microphone or other cables in order that they may at all times be kept at minimum length and within the camera working areas. This studio will accommodate several program production sets arranged around the perimeter of the studio space so as not to block entrances and exits or the visual contact between the several control points and the studio action.

Studio B and its associated facilities shown in Fig. 2 are similarly arranged. This studio is 50 × 83 feet with a 45-foot ceiling. The control room and announce Studio E are similar to the facilities for Studio A. A large scenery painting area separates the two studios and acts as a sound isolation lock between them. Two sound effect rooms, one associated with each studio, and an art room, are located on a mezzanine floor directly above the scenery painting area.

Studio acoustical properties are

OTHER FACILITIES

The studio facilities planned by WCBS-TV and described in this article will supplement the extensive remote facilities that have so far characterized the programming of the station.

Portable equipment includes: mobile unit with three camera chains and shf relay equipment; a similar two-camera chain; three portable camera chains, complete with synchronizing, switching, and monitoring equipment, presently in use at Studio A.

Two complete sets of additional remote facilities, one including shf radio relay, are on order. One set includes a three-camera, and the other a four-camera, chain

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Studio B control room, from the studio

obtained by the use of rock wool blankets hung on the wall and ceiling areas interspersed at random without the usual broadcast studio decorative treatment. Acoustically, each studio is slightly on the dead side of the optimum characteristic for the size of enclosure considered. Control rooms are purposely a little on the live side to represent normal acoustical conditions encountered in an average living room. The studios are made a little dead acoustically in order to reduce ambient noise and also to create less critical sound pickups; in most cases, microphones are located at a much greater distance from performers than in ordinary aural broadcasting. Additional studio reverberation can be obtained by synthetic means. Two methods are available; reverberation chamber facilities, or dialogue and audio perspective equalizers. These latter features are incorporated as a standard part of the CBS Model 3C TV audio control console designed especially for this and similar applications.

Figure 3 is a detail of the left side of Fig. 2, illustrating the arrangement of audio and video control, switching and monitoring consoles, and also the location of operating personnel, in a typical studio control room. There will be three such control rooms in this plant initially, two for the live talent studios and one for handling film and slides. Normal personnel complement comprises one or two technicians, each handling one or two camera control units at the control console. This console is located just inside the observation window that separates the studio from the control room. Several feet behind this console, and elevated slightly, are located the audio technician at the extreme left (facing studio) and adjacent to the turntables (TT), and next to him the switcher who selects camera or other video outputs and preview inputs. He also fades and lap-dissolves video signals and performs other switching and control functions as may be requested by the director who sits at his immediate right. The assistant director is seated to the right of the director. Space has been provided in the control room for clients who are located at a third and higher elevation. Here they can see the preview and line video monitors as well as hear the entire control room action. This arrangement is more clearly illustrated in Fig. 4 which shows the sight lines from each elevation to video monitors, to studio action, and to a large video monitor located above the camera control console.

The simplified video block diagram in Fig. 5 shows the arrangement of facilities associated with Studio A. Similar facilities are provided for Studios B and C, although the latter are somewhat more complex. In Studio A, three cameras, mounted on dollies or pedestals, will be provided initially, with means to accommodate a fourth camera. Each camera control unit, located in studio control, has a 10-in. monitor and waveform indicator. A 10-in. line monitor is also located in the camera control console. The switching, fading, lap-dissolving and other video controls are located on the production console. The switching system is designed to accommodate four studio camera circuits, four film camera outputs, three remotes, and a cue circuit, all of which appear on video jacks in master control. They are also associated with other jacks looking into the relay switching system. There are two preview monitors and one line monitor on the production console. The mixer, stabilizing and isolation amplifiers shown are located in master control.

Studios A and B will each be equipped with a minimum of seven microphones, mostly directional types. The microphones will be used on booms, or suspended from overhead. A minimum of two booms for each studio will be provided. Each of the three studio control rooms will be equipped with model 3C audio control consoles. In order to accommodate the requirements peculiar to television sound pickup and production (as compared to aural broadcasting), it becomes necessary to include provisions for dialogue and perspective equalization, two disc-type turntables, a modified talk-back circuit, a special studio cue circuit, the outputs of film projector sound heads, several remotes, announce studio microphones, reverberation selector and controls, and other facilities necessary in a modern audio control console of this type.

The usual mistake of taking

audio facilities for granted, when considering a new television studio plant, has not been made here. The audio problem includes not only those elements common to network headquarters a-m and f-m requirements, but also entails a considerable number of additional engineering considerations covering the special features required by the combination of sound and pictures. To this end the model 3C television audio console, has been designed to accommodate not only all of the television studio operating requirements, but to afford the greatest flexibility yet demanded.

A suitable intercommunication system will be provided to permit necessary liaison between program director and studio floor manager, between the director and the telecine (film projection) studio, between video switcher and cameramen, between the camera control operators and the lighting operator, and between audio technician and microphone boom operators. Both audio and radio systems of communication will be employed for this purpose.

The Film Studio

The arrangement of film and slide projection facilities with their associated cameras is shown in Fig. 6. T-v film multiplexers are used in order to obtain maximum operational flexibility. Initially, two 35-mm and three 16-mm projectors will be installed, associated with three film camera chains. Two Balopticon projectors will be used with a fourth camera chain and the installation will be arranged so that an additional 35-mm, 16-mm, and slide projector unit may be used with a fifth camera chain. Accessory facilities, including a flying spot scanner, equipment racks, film splicing table and cabinet, and supply cabinet are provided as indicated. Projection controls and video monitors for each of the cameras are mounted on cabinet racks at locations consistent with best viewing. Switches for starting or stopping each of the film projectors are also remotely located on the program consoles in all three studio control rooms.

Master Control

Figure 7 shows the master control room facilities which are located directly over the Studio A control room and Studio C (telecine) areas. The arrangement of the film camera control switching and monitoring facilities are similar in plan and elevation to the facilities utilized in each of the other studio control rooms. The film control facilities are grouped at one end of master control so that if operating experience so dictates, a partition can be installed separating them from other master control audio and video operations. Initially, a curtain will probably be installed between these areas in order to segregate the general lighting and other operating features which are somewhat different from those in master control proper. The master control distribution switching console is located directly in front of twenty-one cabinet racks of audio and video equipment. The rack equipment is arranged so that those units requiring attention from the operating personnel are located on the racks closest to the control console. Fourteen cabinet racks of power equipment are located in a separate room with the panel fronts of six racks facing master control. Two types of standard power supply units for all video equipment in the plant are mounted on these racks and also a few power control and indicating panels. This equipment is segregated so that the 25 kw of heat dissipated can be removed from this space by exhaust fans. This arrangement facilitates air-conditioning the operating area within the master control room where only 10 kw is dissipated.

The audio, video, and power equipment components on the thirty-five racks consist of two sync generators with switching panel, video monitors, video distribution, stabilizing, isolation and fader amplifiers, audio amplifiers, audio and video jack and relay panels, radio relay control units, test equipment, power supplies and their control units, and other equipment. Spare major equipment components are provided. All equipment components are carefully segregated and arranged to allow for future expansion of various parts of the

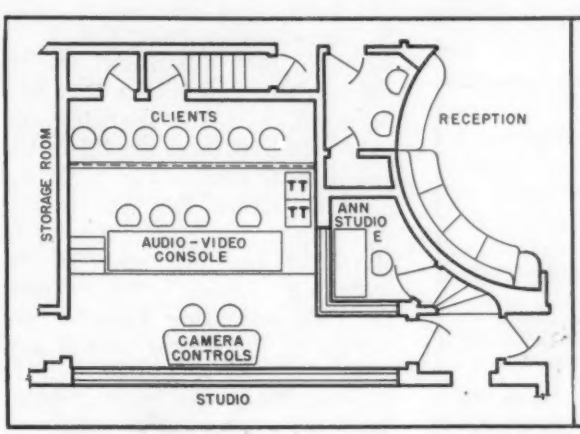

FIG. 3—Studio B control, showing location of technicians, directors, and clients

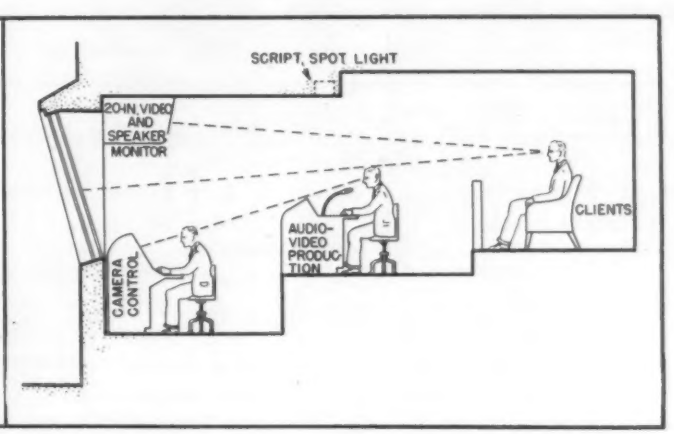

FIG. 4—Elevation view of a typical control room, showing sight lines for occupants. Video monitor indicates television action

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system. For instance, coaxial jack panels, relays, amplifiers, and other equipment associated with the Studio A channel are not only isolated, but rack space is provided for additional units of each type used in channel A.

Announce Studio F is provided for sound commentary associated with film, slide, or other program material. The technical supervisor's office is conveniently located near the entrance to master control; and storage space is provided at the far end of the room for technical spare parts, test equipment, and other necessary supplies.

The master control room is the real center of the system. All video switching is done here. The individual camera lines from each studio camera control output appear on coaxial jacks in this room. However, these lines are normally jacked into the camera switching relays of the corresponding studio. The relays are controlled from pushbuttons on the program consoles in the corresponding studio control rooms. Four banks of interlocked relays are used, two banks for the program switching, fading, and lap-dissolving, and two banks for switching the preview monitors in the program console to any desired input signal. Camera control unit outputs can be patched from one studio to any other control room. In this way, the video switcher at the program console in Studio A control room can switch in cameras from Studio B and from film cameras, as well as from his own local cameras. The signals can be faded, lap-dissolved,

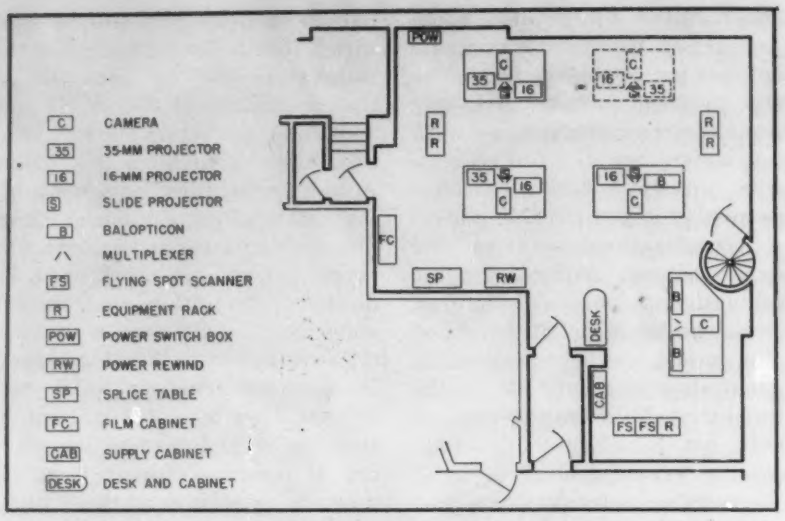

FIG. 6—Layout of equipment for telecine Studio C where motion pictures, transparencies, or opaque illustrations can be fed into the network

or switched instantaneously, between any two of these sources, at the one studio control console.

Remote or network signals can also be patched into any of the studio or film camera switching systems, thus making it possible to switch in remotes as part of a studio or film program if desired. It is possible to switch between local and remote signals but no provision is made for lap-dissolves under these conditions. It is expected that this shortcoming will eventually be eliminated.

The outputs of each group of studio switching relays are mixed in a fader amplifier which is remotely controlled from the corresponding studio program console. The fader amplifier feeds a stabilizing amplifier which clamps on the blanking level and removes switching transients or surges. In addition, synchronizing is mixed in this amplifier with the local camera signals. In cases where remote composite signals are switched in through this system, the local sync mixer is automatically biased off.

The output of each studio switching system is a complete composite signal available for switching to the transmitter or elsewhere. Each of these signals passes normally through jackboard contacts to the master control switching relays. The arrangement of these and associated facilities is shown in Fig. 8, a simplified master control video block diagram.

Three stabilizing amplifiers are used for handling coaxial and telephone line remote video signals. They are required to compensate for the different sync-to-picture ratios in the various incoming signals. In addition, they are useful for removing hum and bounce that may be mixed with the incoming signals. Each of these amplifiers has two outputs available on jacks for patching either into the master control film switching system or to either of the two other studio switching systems. The controls for each stabilizing amplifier are located on the master control console, providing convenient control over the sync and picture levels while monitoring the picture.

The master control switching

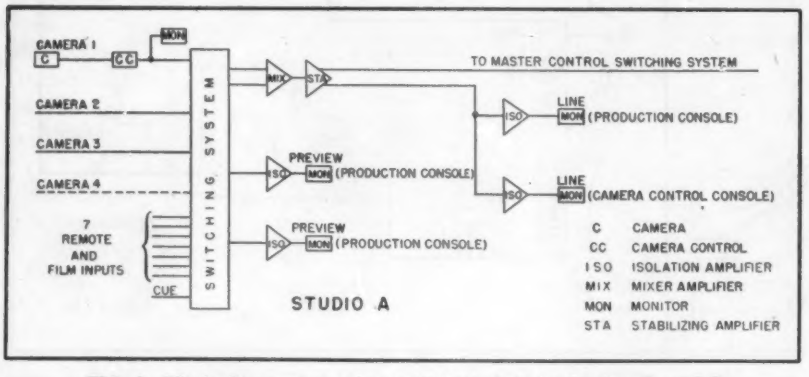

FIG. 5—Block diagram of video switching used in Studios A and B

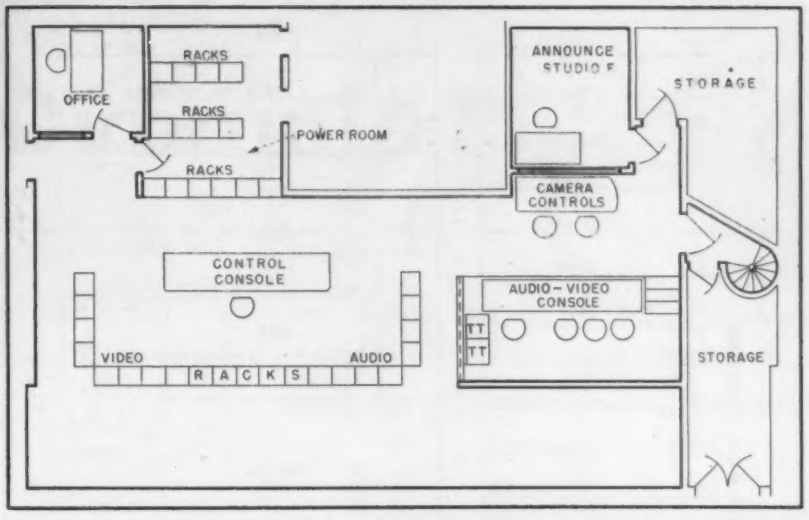

FIG. 7—WCBS-TV Master Control. Camera and associated controls are separated by curtains from main control activities at left

system is arranged so that the desired studio or other incoming signal can be selected to feed the transmitter or other points. This system consists of six banks of twelve interlocked relays each, thus providing for six outgoing circuits to be switched independently to any of twelve incoming signals. Two of these outgoing circuits are used to feed two preview monitors in the master control console. Future video monitors, if required, are indicated by broken lines on Fig. 8. The four remaining lines can be switched independently to any of the incoming circuits. One of these lines will be a network feed. By the use of additional distribution amplifiers, other lines can be fed in parallel with these circuits to take care of monitoring requirements in offices, viewing rooms, studios, and elsewhere. Contacts are available on these video switching relays for the control of simultaneous audio switching.

The master distribution switching desk also contains audio controls, waveform oscilloscopes, volume indicators, a PBX telephone switchboard, and other controls.

Two synchronizing generators are provided in the master control with a switch to select the desired generator for use. This generator feeds distribution amplifiers to supply the blanking, driving, and synchronizing signals to the various parts of the system. All synchronizing, blanking, and driving signal outputs appear on coaxial jacks. Spare outputs are also provided so that substitution can be made easily in case of failure of a distribution amplifier section.

This overall system is extremely flexible as it provides numerous combinations of camera facilities for programming and rehearsal. Cameras and remotes can be patched into any studio switching system so that the program director, at his console in a studio control room, has complete control over the switching of any studio cameras, film cameras, or remotes that he may require to make up a given program. A complete film program can be run entirely in master control if desired. Remote and network programs can also be run entirely by master control when so required. In this way the facilities of an individual studio can be used for rehearsals while another studio is put on the air. One film chain may be used for a program while another film chain is previewed, without interference. Almost any combination of facilities can be used to suit the particular requirements that may arise.

The generous use of coaxial jacks permits quick by-passing or substitution in case of failure of any part of the system. In order to obtain the high degree of operational flexibility described, more than 250 coaxial type jacks and 200 video relays will be employed in this system.

The master control room will be provided with an audio output switching system capable of handling, on a preset basis, the distribution of twelve sources of program to four outgoing circuits. It is complementary to the video switching but can be divorced therefrom if necessary. In addition, ample means will be provided for the equalization of incoming remote loops, for amplification and routing of remote programs, for feeding proper cue to the various studios, and for performing the other miscellaneous functions of a master control room.

Test and measurement equipment for properly determining and maintaining the electrical operating characteristics of all equipment in this new plant, to accord with established standards, is important.[1] Television test equipment presently available is comparable to that available to a-m broadcasting 15 to 20 years ago. Many of the typical laboratory type instruments do not lend themselves well to routine maintenance tests by personnel normally unable to devote full time to the use of such devices.

Test equipment, however, is being provided to enable routine measurements of the audio facilities in determining response-frequency, harmonic distortion, signal-to-noise ratio and signal level. In addition, more complex and expensive test equipment will be provided to enable measurement of video equipment and system performance. This new equipment will permit measurement of the video components and system, including such characteristics as resolving power, response-frequency, phase-frequency, transient response, transfer characteristic, signal level, signal-to-noise ratio, and sweep linearity. Means for accurately determining the timing of composite sync and blanking, and signal conformance with RMA standards, will also be available. It should be noted that only one signal source is necessary for audio performance

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measurements and that eight different signal sources are necessary to determine properly the performance characteristics of video equipment and systems.

Sound Effects

Two sound isolated, acoustically treated and air-conditioned rooms, approximately 15 × 20 feet, each overlooking a studio, will be used for producing sound effects. Audio and video monitoring, communication, and special audio consoles including microphones and mixers, will be permanently installed here. Special power and utility circuits, variable speed turntables, and a record library will also be available. Water supply with necessary plumbing fixtures, and compressed air with necessary controls, will be furnished with which to produce special effects. Many types of physical props will be permanently installed in each room including doors, windows, dresser drawers, gongs, bells, and buzzers. The sounds produced here will be cued in and mixed with audio from studios or elsewhere as may be required. If desirable, the sound effects may be produced in the studio proper or may be reproduced there from loudspeakers. The production of effects in the sound room will be used as much as possible in order to decrease the amount of equipment and cables on the studio floor.

Other Facilities

The primary power supply facilities include approximately 450 kw, of both a-c and d-c power. The audio and video equipment requires about 60 kw of single phase a-c which is available on these premises from two sources. Direct-current power is used for studio and other lighting.

Experiments in studio lighting have gone forward for many months. Although the exact lighting requirements in terms of the new studio image orthicon camera tube, type 5655, have not been fully explored, considerable information has been obtained with five different stage sets in Studio A. This studio is now being operated with live-talent pickups using portable type cameras, and both portable and fixed synchronizing, switching, control and monitoring equipment. Best results to date have been obtained using fluorescent base lighting with about 50 to 100 foot-candles of incident light. This illumination is supplemented with incandescent flood and spotlights which are located for best modeling and high-lighting of the subject or subjects being televised. This high-lighting increases the incident light on the set from 200 to 300 foot-candles. On one particular experimental set, about 18 kw of lighting is used, most of the power being consumed by the incandescent floods and spots. Various types of fixtures and reflectors are used, the objective being to arrive at a standard fixture design which, with adapters, will accommodate various types and sizes of lamps. All fixtures can be elevated, tipped, or rotated by manual adjustment. Because proper set lighting plays an important part in the quality of picture which the televiewer sees, all types of studio lighting are being investigated. It is planned to arrive at a system that has equal flexibility with the audio and video facilities so that the producers of television programs will have available all of the tools necessary to do a first-class job. The lighting for all studio sets will be electrically controlled from a single point. Originally, it was planned to control the physical location of the various light fixtures from a single point. Although the plan has not been abandoned, experience thus far indicates that it may not be practical and economically feasible. All of the lighting facilities will be arranged so that they can be serviced conveniently. Experience indicates that the amount of lighting required will be considerably less than that formerly used with older type iconoscope cameras. This condition is fortunate when considering the comfort of performers and the air-conditioning problem. Studio control rooms and all other operating areas will be lighted with dimmers and spotlights wherever video monitors are located.

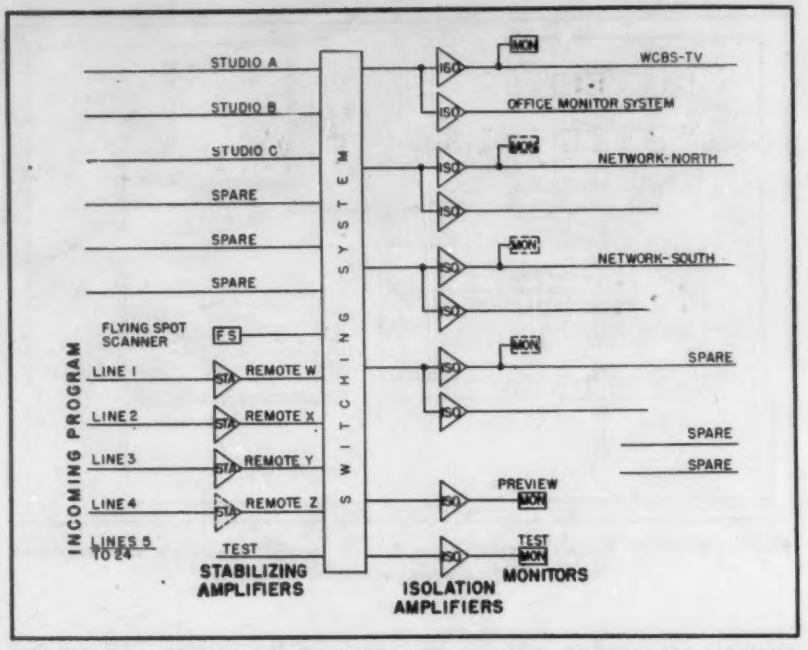

FIG. 8—Block diagram of Master Control video switching, showing mixing of studio and remote program for composite network output

A television studio project of this magnitude requires several thousand engineering man-hours to plan and execute it efficiently. The audio and video engineering work is being performed by the CBS General Engineering Department under the direct supervision of Howard A. Chinn, Chief Audio-Video Engineer.

Reference

(1) D. G. Fink, "Avenues of Improvement in Present-Day Television", a paper delivered before the RMA-IRE Fall Meeting and before the IRE, New York Section.

Dynamic Relay Analyzer

Every aspect of relay action under any operating condition can be measured and analyzed. A cathode-ray display is photographed to obtain permanent records of operate and release time, contact bounce, or other characteristics

By E. L. DEETER
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Front view of the relay tester. Color-coded leads correspond to colored schematic engraved on panel

THE Relay Tester to be described is a versatile instrument that quickly measures the coil resistance, minimum operate current, drop-out current, and voltage drop across the coil of direct-current relays, in addition to the following time periods of the contacts:

(a) Closing time of the normally-open contacts
(b) Opening time of the normally-closed contacts
(c) Closing time, during drop-out, of the normally closed contacts
(d) Opening time, during drop-out, of the normally open contacts
(e) Transfer time of the moving contact, in the operate direction.

The time-check feature is of special interest to the electronic engineer, because it enables him to determine the relay action at the specific current or voltage to be used. By inserting the appropriate impedances or resistances in the relay circuit during tests the actual circuit parameters can be closely simulated.

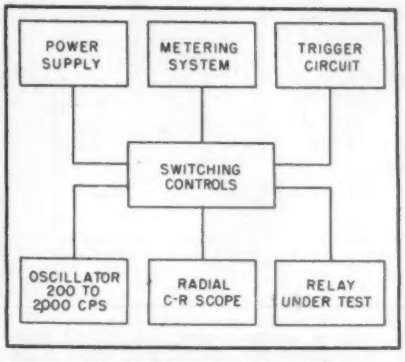

Fig. 1—Block diagram of the relay tester

The circuits incorporated in the relay tester to accomplish these tests are shown in block form in Fig. 1.

Power and Metering

A conventional full-wave power supply is used to furnish relay operate currents up to 1 ampere at 270 volts d-c. A 30-second time delay switch is incorporated in the plate circuits to protect the 866-A rectifier tubes during the warm-up period.

The output of the power supply is fed to a voltage dividing system. By means of a selector switch no-load voltage ranges are available at 0 to 200 and 200 to 1,000 mv, 1 to 10, 10 to 90, 90 to 180, and 180 to 270 volts. Fine adjustments of the ranges are made possible by the use of two tandem arrangements of three 50-watt potentiometers.

The current meter is properly shunted to provide five ranges: 100 μa, 1 ma, 10 ma, 100 ma, and 1 amp. The high impedance voltmeter operates in the following ranges: 3 v (full scale), 10 v, 30 v, 100 v and 300 v. An ohmmeter for measuring circuit, coil, and contact resistance is combined with the voltmeter circuit and indicates resistance in six scale ranges up to 1,000 megohms. The half-scale

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Upper oscillograms show closing time of normally-open contacts, opening time of normally-closed contacts, transit time of moving contact in operate direction, closing time of normally-closed contacts on drop out, and opening time of normally-open contacts on drop out. Lower strip shows various types of contact bounce

ranges are: 10, 100, 10,000 and 100,000 ohms, and 10 megohms.

Relay Timing Circuits

The basic timing circuit is shown in Fig. 2. This circuit, which measures the operate time of the relay, is constructed around the 3DP1 cathode-ray tube. The tube, a radial-deflection type developed for radar use, is similar to the 3AP-1/906-P1, and operates with comparable anode potentials. A 2.5 v filament is incorporated, however, and a radial control anode protrudes through the tube at the center of the screen surface for applying radial control voltages. This anode requires a positive potential from 50 to 75 v, in order to maintain a circular trace within the viewing area of the screen. This requirement is the basis of the timing circuit.

In Fig. 2A, a sine-wave voltage is continuously fed to the deflecting plates through the phasing system including C_1 and P_2. The source of the sine-wave voltage is a stable oscillator covering the range from 20 to 2,000 cycles. A resultant trace will be visible if the proper potential is applied to the central anode of the tube, and the trace will be circular if the phase control is properly adjusted.

A type 3C31 thyratron is utilized as a switch to apply the current to the relay coil and c-r tube anode. This arrangement has two desirable features: the current is applied to the coil instantaneously, without the interruptions that might be encountered if the chattering of a mechanical switch were involved; the thyratron is normally biased with a negative potential that prevents firing. The timing test is initiated when the test switch S_1 is momentarily closed. If the control P_1 is adjusted to a minimum voltage that will just cause firing of the thyratron, the starting point of the trace will repeat itself on consecutive tests. In view of the persistence qualities of the P1-type screen incorporated in the c-r tube, this feature assures ease in making visual observations.

In a test operation the relay is connected to the proper voltage point, as shown in Fig. 2A. The oscillator is set to the lowest frequency, and the phase control adjusted to produce a perfect circle. (A continuous trace will be visible at any time the trace check switch S_3 is opened and the relay test switch operated.) This arrangement makes it easy to check the phase adjustment, which is not affected materially by small frequency changes in the oscillator.

With the relay coil connected to the proper voltage on the voltage divider, the test switch S_1, of the momentarily-on type, is closed. As the thyratron fires, voltage is applied simultaneously to the relay coil and the central anode of the c-r tube. This action causes a trace to appear. The length of the arc described will depend on the oscillator frequency and the time interval between the application of the voltage to the central anode of the tube and its removal, due to the circuit resulting when the normally-open relay contacts close. Let us assume, for example, that the arc appears to be about 180 deg. Because the ultimate aim is to apply a frequency to the c-r tube that causes the arc to close to a complete circle, the frequency is doubled and another trial made, after resetting the circuit by opening the reset switch S_2. This procedure is repeated until the trace just closes to a circle. In practice, this closure may be arrived at in about three trials from start, consuming less than a half minute of time.

It is apparent that the closing time of the normally open contacts, from the time that voltage was applied to the coil, was $1/f$ seconds, where f is the oscillator frequency in cps. It is therefore possible to calibrate the oscillator dial directly in time units, such as milliseconds.

A slight modification of the circuit shown in Fig. 2A, permits the transit time of the movable contact to be measured. The two stationary contacts are connected together as shown by the dotted lines, and during the test the trace will be visible only when the moving

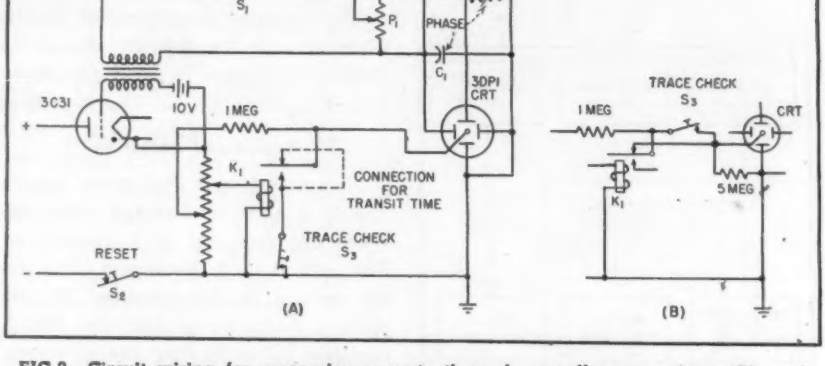

FIG.2—Circuit wiring for measuring operate time of normally-open relays (A), and opening time of normally-closed contacts (B). Transit time is measured by the dashed line modification of circuit A

contact is not touching either stationary contact.

Figure 2B shows another modification of the basic circuit that permits the opening time of the normally-closed contacts to be measured. The trace begins as voltage is applied and disappears when the moving contact of the relay breaks normal contact position.

When measuring the contact times during the drop-out period of a relay, two possible conditions must be considered. The first is introduced when the relay coil is de-energized by means of a series switch and opens into an infinite load where no shunt interferes with the collapse of the magnetic field. The other condition is the one most often encountered in electronic circuits, when the relay is connected in the plate circuit of a vacuum tube not operating with cutoff grid bias. The current through the coil never drops to zero, but varies sufficiently to operate the relay. Under these circumstances the drop-out time is increased. It is, therefore, desirable to be able to simulate either of these conditions when making drop-out time tests on a relay. The basic circuit shown in Fig. 3 makes this possible.

The position of the initiating thyratron V_4 has been changed from its former series connection. When the selector switch of the relay tester is set for closing time of normally closed contacts, voltage is applied to the bleeder to close the relay under test. When the test switch is closed, the thyratron triggers to operate the auxiliary relay K_2, which in turn disconnects the coil of the relay under test. In this manner, the starting point of the c-r trace is still under control. It should be noted that the inclusion of the initiating thyratron at no time introduces any delay in the timing considerations of the c-r trace and its relation to the closing or opening of the relay.

When the test switch is operated the initiating thyratron fires to energize the auxiliary relay K_2. The operation of this relay opens two circuits simultaneously; the grid bias is disconnected from the second thyratron V_3 which then fires to start the timing trace on the c-r tube; the current to the coil of the relay under test is disconnected. When the normally-closed contacts of this relay engage, the trace on the c-r tube is stopped to complete the described timing arc.

The auxiliary relay K_2 is a dpdt relay with adjustable contacts, set in a manner that causes the two moving arms to break contact simultaneously (within 4 to 10 microseconds). This small difference, as well as the delay of V_3 are of such small order as to be unimportant when considering times in the order of milliseconds.

The basic circuit modification shown in Fig. 3B is used to measure the opening time of the normally-open contacts during drop-out. This circuit is similar to Fig. 3A except the anode voltage to the c-r tube is removed, to terminate the timing trace, when the normally-open contacts of the relay under test open.

Binding posts are provided for connecting a series resistance in the coil circuit of the relay under test when the auxiliary relay K_2 operates. The value of this resistance will depend on the circuit conditions in which the relay is to be used, and will take into consideration the d-c resistance of the tube with which it is used, (the series resistance after drop-out), and the current still flowing in the coil.

The six-conductor cable used for connecting the relay to the relay tester is composed of colored wires and terminated in small clips which are convenient for attaching to the lugs of the conventional telephone type relay. A color-coded schematic of a spdt relay is attached to the panel of the tester, and is used as a reference in connecting the relay and in selecting the points desired for voltage and resistance measurements.

Timing Ranges

The oscillator circuit is a resistance-tuned type. Stability has been increased by the use of quality parts with ratings above requirements. The circuit is similar to the Hewlett-Packard 200 Series oscillator. Two frequency ranges are incorporated: 20 to 200 and 200 to 2,000 cps. The millisecond scale of the tester is graduated to read from 0.5 to 5 milliseconds on one scale and from 5 to 50 milliseconds when using the multiplying factor. Operational times from 0.5 millisecond, full trace, to 50 milliseconds, can therefore be read. The c-r screen is divided into four quadrants by means of ordinate lines, and an arc of 45 deg may be estimated, so that approximate readings down to about 60 microseconds can be read at the fast end of the range. Few relays now available will operate in less than 1 millisecond. There are many relays available however, that have operate times of over 50 milliseconds, the extreme limit of the range. If such relays are to be accommodated, the oscillator should have a third range of 2 to 20 cps. Relays with operate times of over one-half second can be tested conveniently on a clock timer.

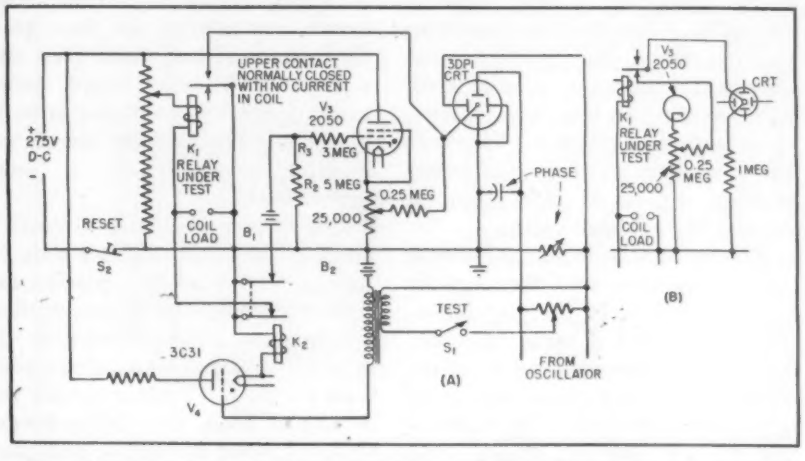

FIG. 3—Schematic circuit diagrams for measuring drop-out time of relays. Circuit A is for relays with normally-closed back contact, and modification B for opening time of normally-open contacts

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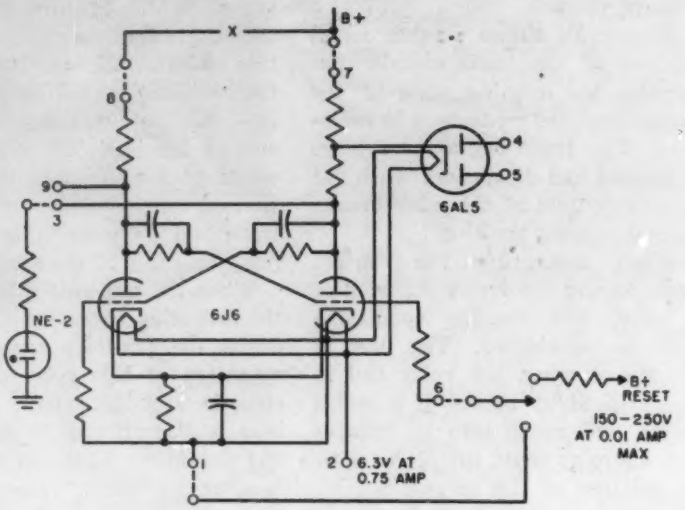


FIG. 1—Duoscale plug-in scale-of-two unit and schematic diagram. Numerals are pin connections for plug. Circuit is modified Eccles-Jordan trigger circuit using miniature tubes

Plug-in Scaler for

Basic scale-of-two counter mounted on nine-pin tube base simplifies design of high-speed counting equipment for industrial and research requirements. Unit can be connected to reset itself automatically on reaching a predetermined count

By CYRIL H. BROWN

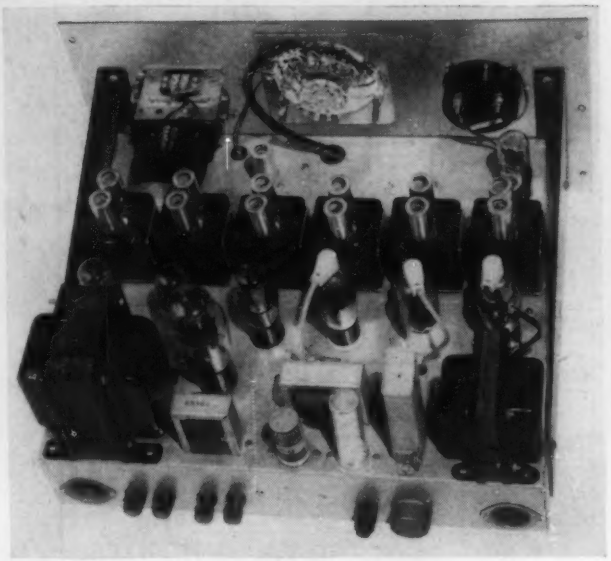
Design Engineer
Tracerlab, Inc.
Boston, Mass.

SCALING DEVICES are used as constant-frequency dividers in any electrical process where impulses are occurring at too rapid a rate to allow dependable actuation of a mechanical register. For instance, small machine parts moving into a packaging machine at the rate of 1,000 units per minute can be counted with an electromechanical counter having a maximum rating of 600 counts per minute by adding a scale-of-two circuit. This allows the register to run at 500 counts per minute, which is within its rating.

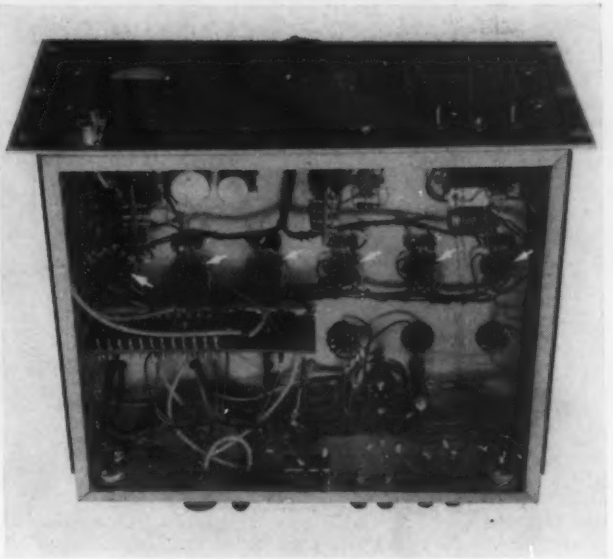
When an electromechanical counting device is used in conjunction with a Geiger-Mueller tube for measurements on radioactive materials, the problems posed by the existence of a maximum counting rate for the register become even more complex. The basis of these difficulties is the unfortunate fact that radiations from the nucleus occur, individually and collectively, at completely random intervals. Even though the average counting rate being measured is not excessive (equal to or less than the maximum rated speed of the register), a sequence of impulses may be received with too short an interpulse spacing to actuate the register. This loss due to random occurrence of pulses becomes serious at rates approximating the register rating.

The use of scaling stages between the Geiger tube and the register greatly improves this situation, since the use of a series of scales tends to decrease the spread or deviation of any individual interpulse space from the mean. It is desirable to use scaling stages even where the counting rate to be measured is equal to or even less than the maximum rated speed of the register, because a system can begin to lose counts well below the rated speed. In actual tests with random pulses, an electronic scaling system rated at 32,000 counts per minute (scale of 32, register maximum rate of 1,000) began to lose at 20,000 counts per minute. In these tests, the same register, when used with a scale of 8 (with rated system speed now 8,000 counts per minute) began missing at 4,000 counts per minute, comparatively a much higher loss.

Use of plug-in scaling circuits in an amplifier-scaler-counter unit for Geiger tubes permits replacing any scale at a moment's notice, without sending the whole chassis to the shop for repairs. A counting circuit used for such a scaling circuit was developed from the Eccles-Jordan trigger circuit by adding grid-plate capacitors between triodes to increase sensitivity and speed up the transfer of conduction from one



Top-of-chassis view of 64-count scaler using six scale-of-two plug-in units. Electromagnetic counter is at upper left



Bottom view of 64 scaler, showing simplicity of wiring. Arrows point to sockets of plug-in units

Industrial Counting

tube to the other. It uses the miniature type 6J6 dual triode, as shown in Fig. 1, with a minature type 6AL5 dual diode as the coupling tube. All electrical connections are made through a nine-prong plug. The scales may be reset in either of two ways: (1) a biasing voltage may be connected to the grid of the righthand triode at pin 6; (2) the plate supply voltage to either of the triodes may be interrupted at pin 7 or 8.

The circuit may be reset so that either the left or righthand tube is normally conducting, permitting use in a predetermined-type scaling circuit, where any number of counts from 1 to 2^n can be counted before the output circuit is actuated. In conventional counting circuits the righthand triode is usually reset to the conducting condition and a scaling ratio of 2^n is available (where n is the number of scales used).

These features, in addition to the fact that the resolving time is of the order of a few microseconds, combine to make this miniature tube plug-in scale useful for many problems of high-speed counting in industry as well as in the research laboratory, for incorporation in such widely varied equipment as scalers for radioactivity measurements and cosmic ray research, microsecond stopclocks using a crystal or tuning fork oscillator and a series of scales as frequency dividers, production line control equipment for counting such objects as machine parts or pills, and constant frequency dividers in any process where events occur too rapidly for direct actuation of a mechanical register.

MANUFACTURING TREND

- Acceptance of electronic equipment by industrial users is greatly increased by plug-in construction of critical sections, permitting instant replacement by unskilled help.
- Cost of keeping set of spare plug-in sections on hand is generally less than a single service call by a factory technician, and there is no machine idle time to be charged up to failure of an electronic component.
- Actual repair of plug-in section can be done at factory on semi-mass-production basis by skilled technicians, insuring effective repair at lowest possible cost.
- Use of plug-ins increases versatility of applications

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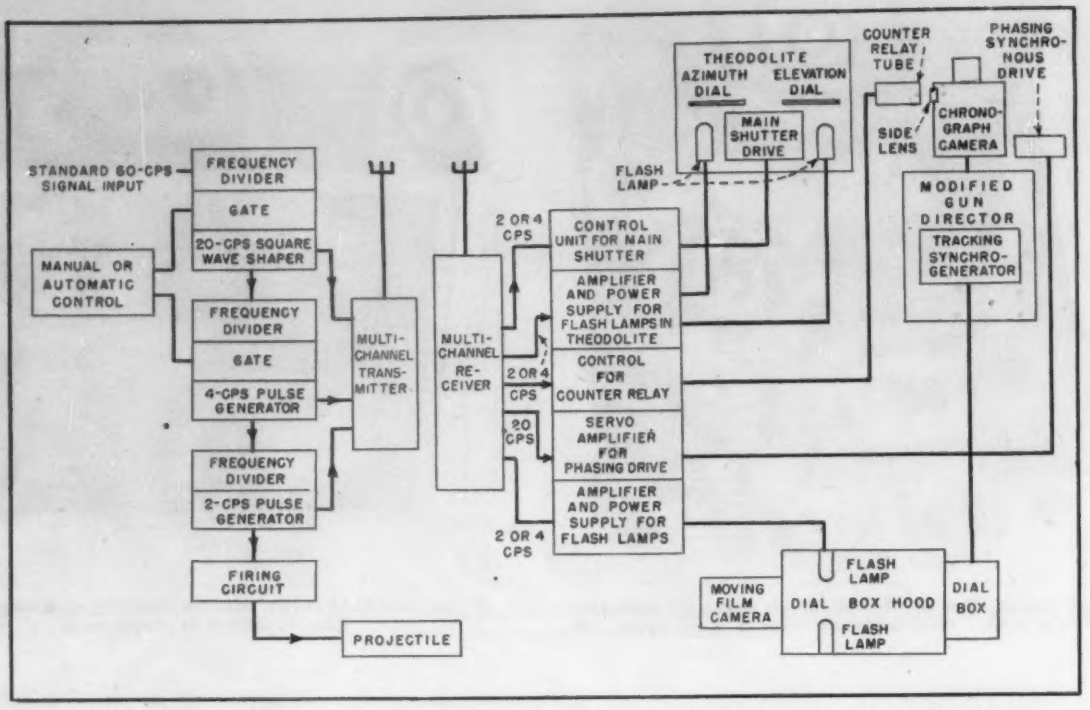

FIG. 1—Block diagram of the camera synchronizing system that is triggered when the projectile is fired. The camera station is common to two or more receiving locations. Position of the missile is recorded by the moving film camera by means of a linkage from the chronograph camera

Photographic Tracking

By L. M. BIBERMAN, S. E. DORSEY, and D. L. EWING

USN Ordnance Test Station
Inyokern, Calif.

PROBABLY the most widely used methods for studying the performance of projectiles and guided missiles are those based on various types of photographic recording. Through the use of a pair or more of camera stations a triangulation can be made to ascertain the position of the "bird" at the time the picture is taken.

It is apparent that any difference in the times at which exposures are made at the several stations will result in an error of computed position roughly proportional to the error in timing and the velocity of the bird, the proportionality being governed by the geometry of the installation. For this reason it was necessary to adopt a timing system for all equipment used in such dynamic triangulation.

Instrumentation

The major instruments concerned are cine-theodolites, which, in essence, are a form of a transit which records bearing-scale readings and the field of view of the telescope including the reference cross hairs. Many such theodolites exist, with varying degrees of accuracy and flexibility. Inasmuch as these instruments are normally tracked in a fairly smooth manner, the error in position determination caused by moderate errors in timing of the recording of the bird in relationship to the cross hairs will not be serious. This is because the cross hairs projected in space must travel at about the same rate as the bird being tracked and the tracking errors correspond to a phase-shift type error which slowly oscillates, so that a timing error of several milliseconds is not serious.

$$\Delta S_A = \left[\frac{ds_o}{dt} - \frac{ds}{dt}\right] \Delta t \qquad (1)$$

where ΔS_A is error caused in recording position of the bird relative to the cross hair by a timing error Δt, ds/dt is the angular rate of bird, ds_o/dt is the angular rate of the cross hair.

A necessary condition for keeping the bird in the field of the telescope is that ds_o/dt be approximately equal to ds/dt.

However, the same timing error applied to the recording of the bearing scales results in an error which is directly proportional to the tracking rate and to the error in timing.

$$\Delta S_B = \frac{ds_o}{dt} \Delta t \qquad (2)$$

where ΔS_B is bearing error caused by timing error Δt

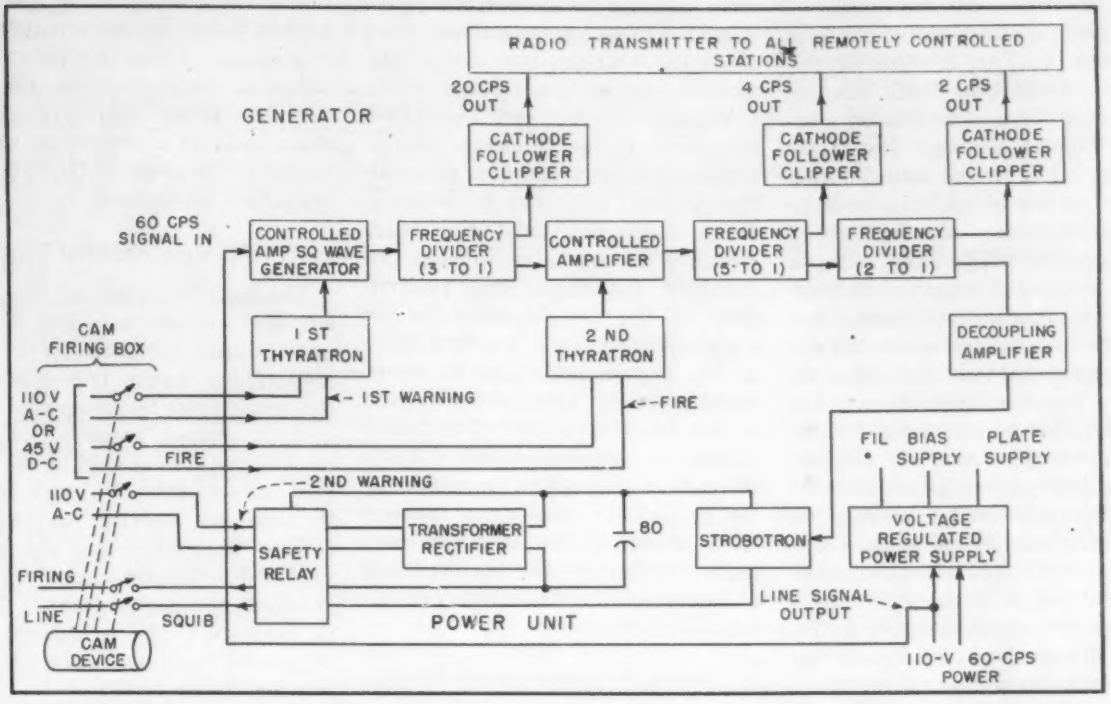

FIG. 2—Block diagram of the firing unit. Control signals are sent out by radio to receiving triangulation stations. Warning sirens at the firing grounds are actuated and the main firing line is open circuited until the safety sequence is complete

# of Guided Missiles

Optical methods used in triangulating on projectiles and missiles are synchronized by radio-links from a central timing standard. Complete automatic firing system including remote three-camera recording station is described

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It is this type of error that has been minimized by the use of a central timing source which transmits a series of timing pulses to the various units via a radio link system. A block diagram, Fig. 1, shows elements of the system.

Camera Equipment

The outputs of the receivers at the various stations are separated and fed through cathode followers to the individual control amplifiers, which are of two general types. One control amplifier operates the main field-camera shutter, recording the position of the bird with reference to the cross hairs of the instrument. The second type is a pulse amplifier for operating type FT-14 Edgerton flashlamps to illuminate the bearing scales and thus act as a precisely timed high-speed shutter.

The main field shutter controls are of two types. One amplifier operates the solenoid-activated, louvre-type shutter of the pulse-operated cameras, while the second is a servo amplifier for synchronizing and phasing the main field drive of the more usual motion-picture camera. An additional amplifier operates a counter at preset intervals to mark and identify the various frames on the camera. Thus a given record will indicate exact relative time at which the picture was taken, the azimuth and elevation angles of the optical axis of the telescope, and the angular position of the bird relative to telescope axis.

Timing Generator and Firing Unit

In order to insure the safety of all personnel concerned in the firing of ground-launched missiles a safety-interlock system is necessary. In addition, a warning is given and three supplementary warning horns are used for aural indication of the approaching firing. These devices are controlled by a cam system contacting snap-action switches in a given preset order. This same cam system can be used to energize camera motors when

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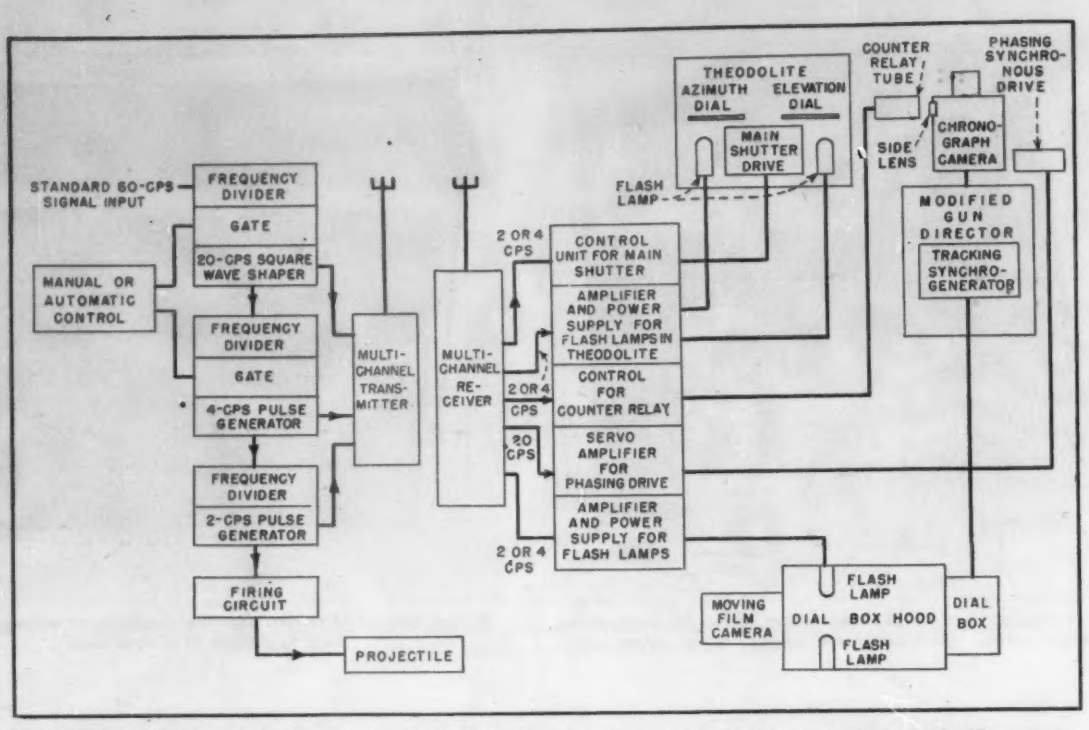

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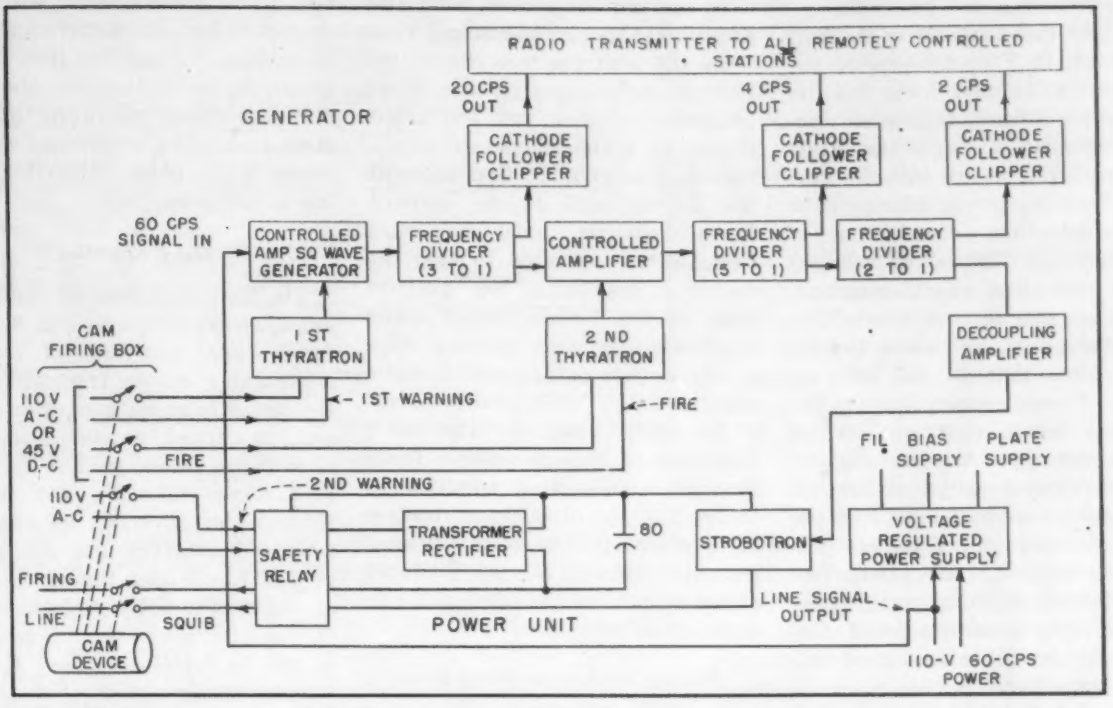

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precise timing is not required.

The general functions of the unit are shown in Fig. 2. One of the switches in the cam firing box, on momentary closure, injects an electrical impulse through the First Warning siren circuit into the grid of the first thyratron, causing it to start conduction. Conduction of this thyratron adjusts the voltages of the controlled amplifier-square-wave generator so that it amplifies and clips into square waves the 60-cycle signal that is fed into its input. These square waves, fed into the 3-to-1 frequency-divider circuit, emerge from its clipper-cathode follower output as 20-cycle rectangular positive pulses, with the same reference level of voltage (adjusted to zero volts) after the pulses have started as there was before. Another output of the 3-to-1 frequency divider feeds the second controlled amplifier.

Following the time sequence and the diagram, the second operation is the closure of the switch in the cam firing box which applies 110-volt a-c power to the Second Warning horn input. The application of power at this input actuates a safety relay, causing the transformer-rectifier combination to charge the 80 microfarad capacitor. It is the later discharge of this capacitor, through the Strobotron, that fires the projectile at the moment that the controlling impulse appears on the Strobotron grid.

When the firing of the round is desired, momentary closure of the firing switch either manually, automatically, or both in the cam firing box actuates the second thyratron through its input (Fire) terminals, causing the second controlled amplifier to become operative. Then when the next positive rise of the 20-cycle output occurs, the 5-to-1 frequency divider and the 2-to-1 frequency dividers operate simultaneously to give the first pulse on the 2-cycle and 4-cycle outputs. From then on, until the reset switches are operated to stop the counting sequences, the positive rises of the 2-cycle output occur simultaneously with positive rises of the 4-cycle output, which occur simultaneously with positive rises of the 20-cycle output. The 2-to-1 frequency divider also feeds through a decoupling amplifier to the grid of the Strobotron, causing it to discharge the 80-microfarad capacitor through the squib circuit at the moment of the start of the 2- and 4-cycle outputs.

Phasing Synchronous Motor Drive

A special drive system was designed to enable operation of several Mitchell chronographs in phase at a speed of 20 frames per second. Essentially this unit consists of a synchronous motor operating through a reduction-differential gear system with an output of 1,200 rpm. The output shaft carries a one segment commutator for generating a pulse approximately 15 electrical degrees wide. The output of the servo amplifier described below operates a reversible series motor which varies the output speed from 1,200 to some other value until the pulse from the commutator is in phase with the reference pulse generated by a centrally located pulse generator. When the pulses are in phase owing to the positioning action of the phasing motor, a brake is applied to lock the differential shaft in position. From this time on the phase is maintained by the synchronous motor operating at constant load. If a power-load change causes a line phase shift, the phasing action is resumed.

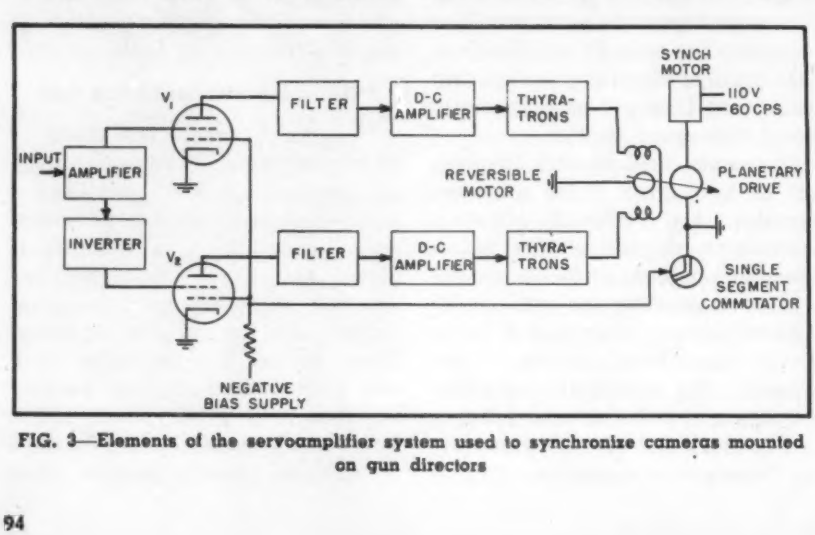

FIG. 3—Elements of the servoamplifier system used to synchronize cameras mounted on gun directors

Servo Amplifier

The basic divisions of the servo amplifier are shown in Fig. 3. The input signal, composed of 20-cycle rectangular waves transmitted to the device from the generator firing unit, is clipped, amplified, and applied to the second grid of the dual-grid mixer tube V_1, and passed through an inverter, so that its reverse is injected into the second grid of V_2. Within limits, the ratio of length of positive peaks to length of negative peaks is unimportant, as will be explained later. Excitation for the first grids of V_1 and V_2 is in the form of positive pulses, generated by the contactor and one-segment commutator mounted on the camera driveshaft. Since the contactor is connected through a high resistance to the negative bias supply and the segment is grounded, intermittent connection between the two for a few degrees of rotation creates these pulses.

The operation of the remaining portion of the amplifier is to cause the d-c motor to hunt for a phasing condition such that the center of the contactor pulse coincides with the positive rise of the input signal. Figure 4 shows graphically the various conditions imposed upon the mixer tubes. Where the pulse lags, as shown in condition 1, it is impressed on the first grids of the mixer tubes, while the second grid of V_1 is positive and that of V_2 is not positive. Since the second grids of these tubes must be positive if the tube is to conduct, V_1 conducts for the duration of the pulse but V_2 does not conduct at all. Conduction in the tube drops its plate voltage, as shown in the diagram. These pulses are averaged out by the filter circuit, the average value is amplified by the d-c amplifier, and the resulting positive rise of voltage is imposed on the grids of the thyratrons, causing them to conduct. The output of these thyratrons is connected to the d-c motor in such a

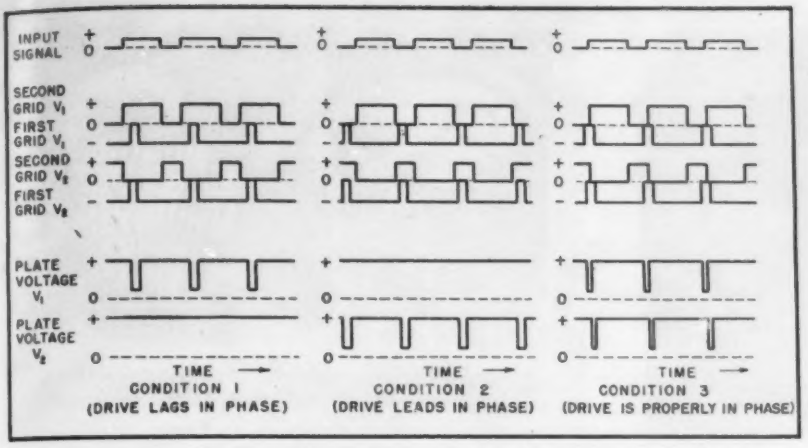

FIG. 4—Voltage patterns showing conditions that lead to automatic synchronism of tracking cameras

manner that it is driven in the direction which will correct the phase lag.

In condition 2, just the opposite is true: the contactor pulse leads the positive rise of the input signal, bringing about conduction of V_2 instead of V_1. The result is a positive rise in the grid voltage of the lower thyratrons. Conduction of these thyratrons drives the motor in the direction which will correct the phase lead.

In condition 3, the pulse is shown properly in phase with the positive rise of the input signal. The first half of the pulse causes conduction in V_1, the second half in V_2. The resulting pulses, after being integrated by the filter and amplified by the d-c amplifier, produce a signal not great enough to appreciably affect either thyratron circuit. Thus, the d-c motor, receiving insufficient current to be driven, is held locked by its brake into the proper position to phase the drive of the camera within a few degrees.

Power and Control

In the block diagram (Fig. 2) the plate and bias supplies, including the circuits necessary to bias the thyratrons properly, are not shown. There is also a circuit which prevents the application of voltage to the thyratrons and the synchronous motor until two conditions are met. Sufficient time must have elapsed for the cathodes of the thyratrons to reach operating temperature and there must be a signal on the input of the unit.

The counter relay tube (Fig. 1) contains a high-speed counter relay and a group of four 28-volt lamps in two circuits, each made up of two in series, and physically placed to illuminate the counter registers. This tube is placed so that the counter is photographed, when illuminated, by the chronograph lens of the Mitchell camera. The synchronization of film and lights is described below. The counter relay amplifier is connected to the radio timing receiver from which it is fed 2- or 4-cycle pulses. The amplifier sends out three pulses simultaneously, one to the counter relay and one to each lamp circuit. Since the chronograph is phased, the chronograph lens is open at the instant of flashing of the lamps. After the flashing of the lamp (owing to the small delay of the counter mechanism) the counter register advances one number, thus every tenth (or fifth) frame in the chronograph is numbered to furnish a definite reference for the film assessor.

The synchro dial box contains five type 5F servo motors, four of which are tied into the coarse and fine elevation, and azimuth synchro generators in the Mk 51 Mod 3 director. The synchro motors carry engraved dials mounted behind a mask to aid in assessing data. The synchro dial box is illuminated by two FT-14 Edgerton lamps powered by the flash-lamp amplifier. The flash-lamp amplifier is triggered by 20-cycle, 4-cycle, or 2-cycle pulses from the radio timing receiver. As a result, three recording ratios can be used: one, five, or ten frames of the chonograph to one frame of the dial box camera. This latitude allows detailed study of angular rates at 20 fps or angular positions at 2 fps along with the 20 fps chronograph record for study of round performance. Such a system allows a continuous-record film to be used for position data as well.

35-Mm Master Recorder

Another camera is designed to serve as oscilloscope recorder, dial box recorder, operations recorder, or combination dial box and operations recorder. This instrument is a continuous-drive 35-mm camera with interchangeable aperture plates for single and double-frame use. The aperture plate is mounted in a lamp house containing two neon lamps, each located behind a 0.006 in. hole centered vertically at the edge of the aperture plate. These lamps can be used to record as a series of dots on the edge of the film the operation of some two mechanisms connected through suitable amplifiers.

The Askania theodolite shutters are pulsed with an inherent delay of about 20 to 30 milliseconds because of mechanical linkages. The normal bearing-scale shutters and incandescent light which served to illuminate the bearing dials and expose them to the film at the proper time have been removed. In their stead is a flashlamp installation, which can be pulsed with resultant bearing-scale timing errors under one hundred microseconds.

Acknowledgments

The system has been used in part and as a whole for various guided missile and rocket studies carried on at this station for about a year. The system is part of a long development program carried on by the Exterior Ballistics Section. The authors acknowledge the close teamwork of Arden H. Milam, John DePangher, Norman Littrell and Joseph Hirsch in Mechanical Design. The recent electromechanical counterpart of the firing-pulse generator now commonly used and the radio link system were engineered by E. R. Toporeck and A. B. Vane of the Electronics section of this station. The general cooperation of N. A. Renzetti and J. Titus assisted the development considerably.

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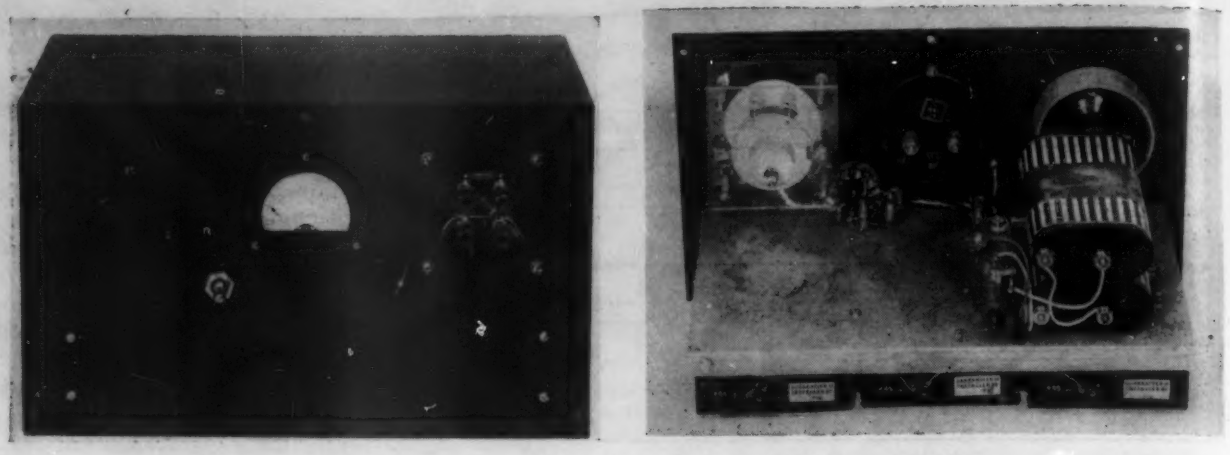

Front and rear views of the diode noise generator for receiver measurements

Noise Generator for

By PETER G. SULZER

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Department of Electrical Engineering
The Pennsylvania State College
State College, Pa.

TWO significant sources of noise are associated with a radio receiver. One is made up of all of those within the receiver itself, such as shot effect and partition noise. The other source is the thermal agitation (Johnson) noise supplied by the resistive component of the antenna impedance. The noise figure[1, 2] of a receiver is defined as the ratio of the sum of these two to the second, or,

$$F = \frac{P_r + P_a}{P_a} \qquad (1)$$

where P_r is the equivalent noise power output of the receiver referred back to its input terminals (that part in excess of thermal noise), and P_a is the thermal noise supplied to the receiver by the antenna. A perfect receiver would have P_r equal to zero, and the noise figure would be unity. This definition is not very explanatory; the reader should see the first two references for a full discussion of the subject.

It is easy to calculate P_a, but P_r is difficult to determine directly. However, the sum $P_r + P_a$ may be determined by a simple expedient. The noise power output of the receiver is measured when a resistance R_a, which is substituted for the antenna, is connected across the antenna terminals. Next, a temperature-limited diode is connected as shown in Fig. 1 and the direct diode current I is adjusted by varying the filament temperature to such a value that the noise power from the diode doubles the power output of the receiver.

Under these conditions, $P_{diode} = P_r + P_a$, and

$$F = (P_r + P_a)/P_a = P_{diode}/P_a \qquad (2)$$

It is now necessary to evaluate P_{diode} and P_a. The rms fluctuation current from a temperature-limited diode is[3]

$$i^2 = 3.18 \times 10^{-19} IB \qquad (3)$$

where i is the rms fluctuation current in amperes, I is the direct diode current in amperes, and B is the bandwidth in cycles per second. If the input resistance of the receiver is R, the diode sees a load resistance R_aR/R_a+R, and the diode delivers to the receiver a power

$$P_{diode} = 3.18 \times 10^{-19} IB\,(R_aR/R_a + R)^2\,1/R \qquad (4)$$

A resistance will develop a thermal-agitation voltage across its open-circuited terminals $e^2 = 4KTR_aB$, where K is Boltzmann's constant, 1.374×10^{-23} joules per degree Kelvin, T is the absolute temperature of the resistor in degrees Kelvin, and B is bandwidth in cycles per second. It is assumed that R_a is constant over this frequency band.

The resistor will deliver a power to the receiver

$$P_a = \frac{4KTR_aB}{R_a + R}\left(\frac{R}{R_a + R}\right) \qquad (5)$$

Substituting Eq. 4 and 5 in Eq. 2,

$$F = \frac{5{,}790}{T} IR_a \qquad (6)$$

For a temperature $T = 289$ degrees Kelvin, 19 C,

$$F = 20\,IR_a$$

Since the bandwidths cancel, noise figure measurements made in this manner are independent of the response curve of the receiver. Since quantity R, the input resistance of the receiver, does not appear, the measurements are not in error because of the mismatch between R_a and R, and the effects of such mismatch on noise figure can be studied.

The factor R_a in the expression requires some attention. A temperature-limited diode should, at first glance, appear to have an infinite a-c plate resistance. However, the work-function of the filament surface depends on the anode voltage[4]. The result is that emission in-

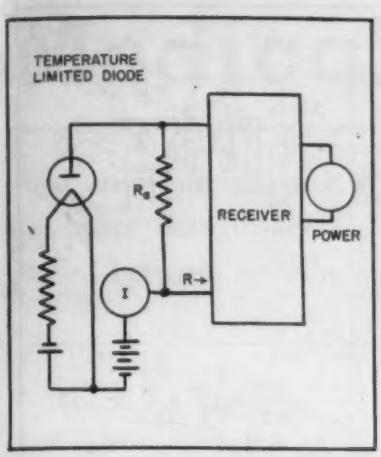

FIG. 1—Basic circuit for measurement of noise figure with a noise diode

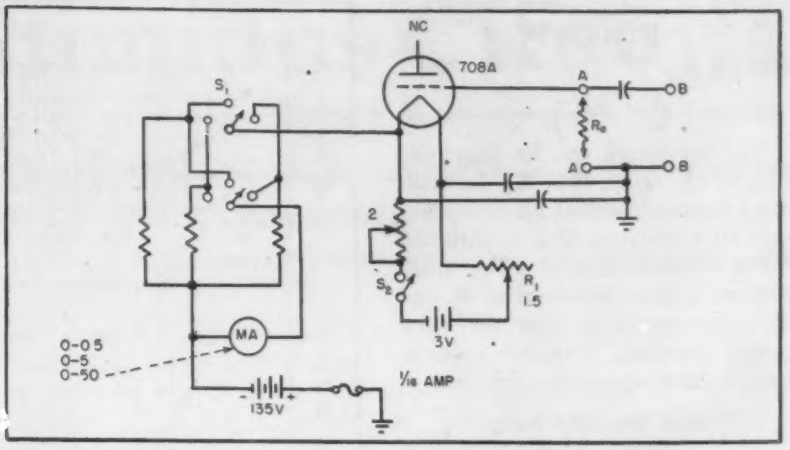

FIG. 2—Schematic diagram of the diode noise generator. The receiver connects to points *A-A* normally, to *B-B* if d-c isolation is required

Receiver Measurements

Diode noise generator permits simplified procedure in the measurement of noise figures and receiver input resistance. The receiver bandwidth need not be known and measurement is independent of the response curve of the receiver

creases with increased anode voltage, and the a-c plate resistance becomes finite. When high values of R_s are used, the plate resistance must be considered in parallel with it.

Resistance R must have the desired value, and must remain constant over the frequency range used. At the higher frequencies, the use of film-type resistors is desirable.[6] It has been found by slotted-line measurements that Allen-Bradley fixed resistors and Type J potentiometers of 1,000 ohms or less resistance are suitable at least as high as 400 megacycles.

Use of Diode Generator

It was stated that measurements are made by noting the diode current necessary to double the output of the receiver. Thus, the use of an output meter is indicated. However, calibration is usually necessary because of the nonlinearity of the detector. If a signal generator is available, it can be used. If not, the diode generator itself will serve the purpose.

The noise diode and R_s are connected to the receiver, and the diode itself is turned off. The r-f gain control of the receiver is turned down until the output meter nearly indicates zero. Under this condition the gain is so low that the noise power from the receiver and from R_s can be neglected, and the output power of the receiver will then be directly proportional to I.

The diode current I is then increased until some convenient output reading—say one volt—is obtained. The diode current I is then doubled, and the output reading is noted. If the detector is linear, the reading will be 1.41 volts. If not, it will probably be higher—perhaps 1.5 or 1.6 volts. The increase from 1 volt to the higher value does indicate a true doubling of the input power.

If the receiver has an a-f or video gain control, its setting must not be changed after this calibration is made, since it is necessary that the detector operate over the same part of its characteristic. It may be necessary to use a high value of R_s to obtain sufficient input to the receiver for this calibration.

The input resistance R of a receiver can be measured by a method given by A. van der Ziel.[7] A somewhat simplified version of his method follows.

The noise diode is connected to the receiver input terminals, with the diode inoperative, and with $R_s = \infty$. The receiver gain is decreased until the output indicator drops nearly to zero. The diode filament temperature is increased until a current I is obtained, and the output reading is noted. With reference to Eq. 3, the input power to the receiver is given by

$$P = 3.18 \times 10^{-19} I_1 BR$$

Next, a finite value of R_s is used, and the diode current I is adjusted for the same output reading as before. It will be necessary to use a higher value of I, I_2, because part of the diode power output is absorbed by R_s. The power input to the receiver is given by Eq. 3, and is the same as that obtained with I_1 when $R_s = \infty$. Equating the powers,

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$$3.18 \times 10^{-19} I_1 BR = 3.18 \times 10^{-19} I_2 B \left(\frac{R_e R}{R_e + R}\right)^2 1/R$$

Solving for R,

$$R = R_e \left(\sqrt{\frac{I^2}{I^1}} - 1\right) \quad (8)$$

The procedure can be simplified if $I_2 = 4I_1$. Then $R = R_e$. In making the measurement in this manner, an output reading is obtained for a diode current I. The diode current is then increased to $4I$, and R_e is decreased to give the same output reading. Detector calibration is unnecessary for this test.

Noise Generator Design

In the noise generator circuit of Fig. 2 a type 708A triode is used as a diode, the control grid being used as the anode. The plate is not connected. The 708A was chosen because it has high grid-dissipation capabilities, low grid-filament capacity, and a thoriated tungsten filament whose temperature responds rapidly to changes in applied voltage.

Filament voltage is controlled by a rheostat R_1 which is used to set the diode current I to the desired value. In practice it may be necessary to measure noise figures as high as 50 with values of R_e as low as 50 ohms. This requires direct diode currents as high as 50 milliamperes. The meter was provided with shunts for full-scale currents of 50, 5, and 0.5 milliamperes.

The tube is mounted on an insulated panel with terminals for R and for connection to the receiver. Every effort has been made to keep the output capacitance as low as possible $-10\mu\mu f$ in this case. At frequencies where the reactance of this capacitance becomes comparable to R, it is necessary to tune it out by means of a coil or, at very high frequencies, a Lecher wire system.

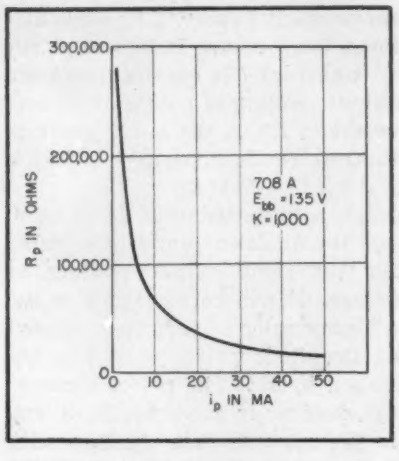

FIG. 3—Plate resistance versus plate current for the 708A tube

Figure 3 is a plot of R_p versus i_p for the 708A. It can be seen that R_p will be much higher than R_e under almost all circumstances.

Results

The choice of a diode for this use is a difficult one because almost all small diodes made in this country have oxide cathodes and are not suitable. It is to be hoped that a tube designed specifically for this application will be manufactured. A small diode constructed from the plate and filament of a 316A doorknob tube and mounted in a tubular envelope for probe use should be ideal for measurements, at least up to the vhf range.

The results of some measurements made with the diode noise generator are shown in Fig. 4A and 4B. The two amplifier circuits shown were used as preamplifiers for a Super-Pro receiver. The push-pull neutralized 6J6 gave the lowest noise figure; a ratio of about 1.2. This value is doubtful to about ±0.2 because of the external noise pickup. The minimum noise figure was obtained with a value of R_e less than the input resistance R; 150 ohms as compared with 200 ohms.

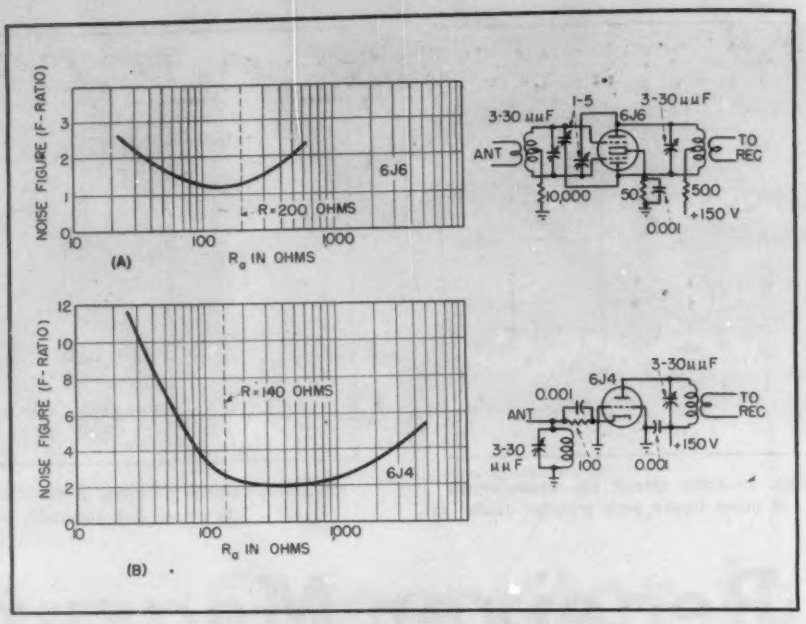

FIG. 4—Preamplifier circuits and measurements

The input resistance was measured by two independent means to provide a check on theory. The noise diode gave a value of 200 ohms; 220 ohms was obtained by substitution with a signal generator.

The 6J4 preamplifier shown in Fig. 4B gave a minimum noise figure of about 2. This is not quite as good as the 6J6, but the circuit has the important advantages that the tuning of the input circuit is not critical and neutralization is not required.

Input resistances of 140 ohms and 130 ohms were obtained with the diode and signal generator respectively. The measurements were made at 20 megacycles.

The assistance of Arthur H. Benner in the construction and measurements is gratefully acknowledged.

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Medical Stimulus Circuits

New electronic circuits for medical diagnosis and research include outline wave-shape generator that produces any desired waveform when its shape is cut from cardboard and placed between c-r tube and multiplier phototube. Recording circuits are also discussed

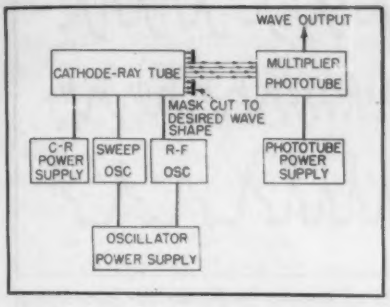

FIG. 1—Block diagram of system for generating stimulating current whose waveform is cut out from cardboard mask

By W. E. GILSON*

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IN biological research it is frequently desirable to have available a source of stimulating current of unusual wave-shape, slope, and frequency. These characteristics are usually difficult or impossible to obtain by means of ordinary electronic circuits.

The device to be described was designed to provide either single or repetitive stimuli derived from a simple silhouette easily cut by following any desired curve drawn on cardboard or similar material. The mask so obtained is placed in contact with the screen of a cathode-ray tube having a short-persistence phosphor.

The block diagram of this variable wave generator is shown in Fig. 1. The beam of the cathode-ray tube is spread vertically into a thin line by a radio-frequency oscillator connected to the vertical deflecting plates. The line thus formed is caused to move from left to right between two definite end points on the silhouette. The motion is obtained by the relaxation oscillator circuit of Fig. 2, using fixed break-down point and a double-thyratron discharge path to provide a quick return. The accuracy of the break-down point at the right is obtained by a thyratron so biased and connected that it will fire when the voltage on the sweep capacitor reaches a predetermined point. This sends a positive pulse into the grids of the parallel sweep-actuating thyratrons, causing them to fire.

No special precautions are necessary to provide a stable end-point at the left as the voltage drop across the tube and the deionization voltage vary only slightly.

An RCA 931-A or similar multiplier phototube is placed about eight inches from the face of the cathode-ray tube. The amount of light which falls on the phototube is a function of the length of line which it sees at any instant and this is determined by the shape of the mask. The output of the phototube is approximately 10 volts with a 750-volt power supply and a 50,000-ohm load resistor.

The d-c power supply used consists of a half-wave rectifier (2X 2/879) and a pi-section filter using two 2-μf, 1,000-volt paper capacitors and a 300-henry audio choke with 1,600-volt insulation.

The light-sensitive surface of the phototube is of proper size so that no lens system is necessary to provide uniform output for a given length of line at any position between the fixed end points of the mask, provided the distance from the screen to the phototube is not less than eight inches.

The output of the phototube may be amplified by a d-c amplifier and applied to the organism, as desired. Examples of the wave shapes obtainable are given in Fig. 2.

The frequency so obtained is lim-

Square-wave stimulator, showing technician applying stimulus to muscles of forearm

* R. Pavlat of the University of Wisconsin Medical School is coauthor of the first portion of this article, covering the outline wave-shape generator.

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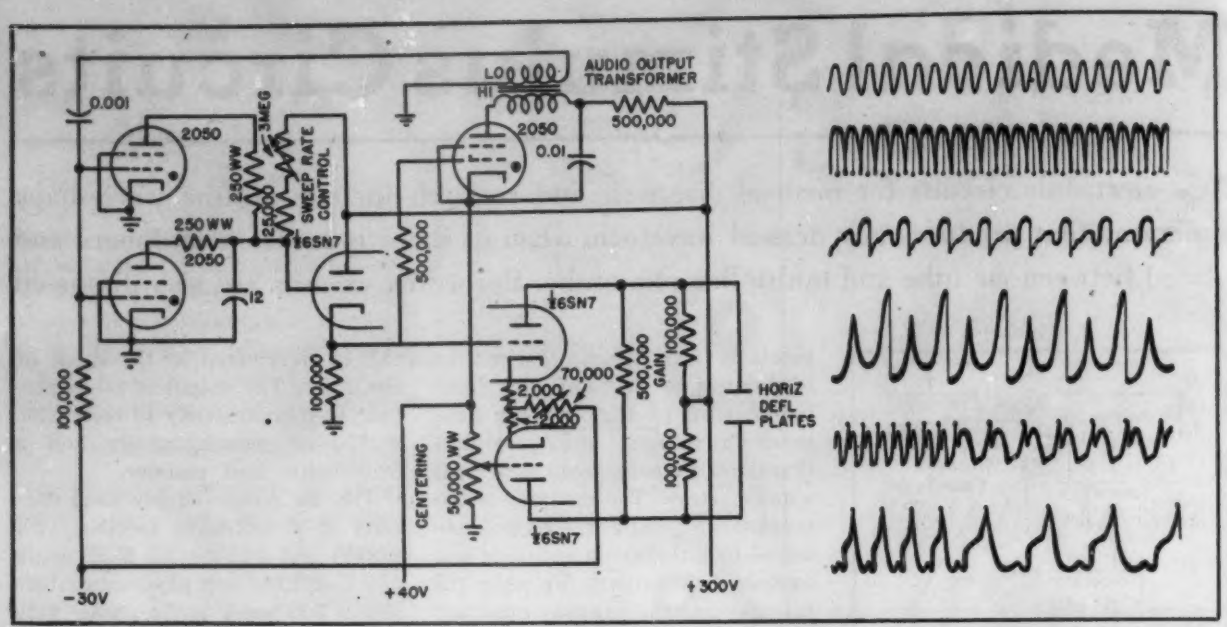

FIG. 2—Relaxation oscillator circuit used to sweep vertical-line trace across cut-out mask at desired frequency for generating medical stimulating current, and examples of waveforms generated. Lower two records show result of varying sweep rate

ited by the phosphor decay characteristics (the light output is down to 10 percent in 3.3 milliseconds with an RCA-11 phosphor). In the circuit used the lowest sweep frequency is about 1 in 10 seconds.

Square-Wave Stimulator

For purposes of diagnosis in nerve and muscle lesions it was desired to have available a square-wave stimulus with accurately preset current flow, independent of tissue and electrode resistance, and with separate adjustments for length of stimulus and frequency of stimuli. The latter adjustment appeared preferable to varying the interval between stimuli.[1]

The circuit of the stimulator is given in Fig. 3. Here T_3 and T_4 are connected as a one-shot multivibrator with T_4 normally fully conducting and its plate thus relatively negative. When a positive pulse is momentarily applied to the grid of T_3 it becomes fully conducting, and T_4 is cut off. Its plate then becomes relatively positive for a length of time determined by the size of the capacitor selected and by the 2-megohm resistor. The time in seconds is approximately equal to the value of the capacitor in microfarads.

The plate of T_3 is connected to the grid of T_6, the bias of which is varied by the *STRENGTH* control. In the normal quiescent condition T_6 is biased beyond cutoff, so little or no current flows. During the stimulus period the grid is less negative and current will flow, the amount depending on the setting of the *STRENGTH* control. Because of the current-regulating characteristics of T_6, the amount of resistance in the patient circuit makes little difference between 0 and 20,000 ohms.

The frequency of the stimuli is controlled by selecting capacitors in the plate circuit of T_1, which is connected as a relaxation oscillator. Each time the capacitor discharges through T_1, a positive pulse is transmitted to the grid of T_2 by the transformer in its cathode circuit. This triggers the one-shot multivibrator.

The frequency per second is equal to 1 divided by the capacitance in microfarads. Position 1 on the frequency control switch is for a single pulse provided by manual operation of the pushbutton. Because the 500,000-ohm resistor is connected to a less positive point than the 750,000-ohm plate resistor of T_1, the 0.1-μf capacitor will not become charged to the breakdown point of T_1. When the *MANUAL* pushbutton is pressed the bias on T_1 is momentarily removed for a period of time determined by the time constant of the resistor and capacitor in the grid circuit of T_1. This causes the tube to break down and provides a single square wave from the multivibrator.

The output of the stimulator may be connected either to a test resistor or to the patient. The approximate strength stimulus desired is usually set with the output connected to the resistor and with a long square wave so that the meter reading may be adjusted easily.

The output may be reversed by the reversing switch, so that either a negative or positive voltage is supplied to the active stimulating electrode.

In some cases it is desirable to surge the current applied to the patient, for automatically increasing and decreasing the stimulus. If the *SURGE* switch is turned on, the screen voltage of output tube T_6 will be controlled by relaxation oscillator T_7 through cathode-follower amplifier T_8.

Physiological Recording System

For recording circulatory phenomena in man it was desired to have a system capable of reproducing the electrocardiogram, the amount of blood in the ear, and several other graphs of physiological functions. The electrocardiogram could well be the standard 1 cm per millivolt size with an excursion of about 2 cm, but an excursion of several inches was necessary in order to show small variations in

ear volume. This made the use of a beam of light the method of choice. A camera using 12 or 18 inch-paper was devised in collaboration with J. S. Hipple.[2]

In order to simplify the optical system it was decided to use a galvanometer with a large mirror, eliminating the need of a high-intensity arc or incandescent light. The Sanborn Cardiette galvanometer proved to be satisfactory. It had a mirror approximately $\frac{1}{4}$ inch in diameter; when this was replaced by a Leeds and Northrup mirror of the same size, with a working distance of 1 meter, galvanometer lenses were not needed. This simplified construction and eliminated loss of light in the lenses.

The circuit of the direct-coupled amplifier used is shown in Fig. 4. This amplifier is suitable for operation with a photoelectric plethysmograph or photoelectric membrane-manometer.[3, 4] The amplifier is extremely stable as it incorporates a large amount of cathode degeneration. The operation is as follows: the input grid is connected to ground by means of switch *SW*. The gain control is turned to maximum and the center control adjusted so that the light beam is returned to approximately the same position it occupied before the amplifier was turned on. The gain may next be reduced and the grid connected to the input. The balance control is then used to balance the voltage drop in the phototube load resistor with the basal amount of light falling on the phototube. This brings the light spot back to approximately the same position. The gain may then be adjusted so that the desired deflection is obtained.

Figure 5 shows the electrocardiograph amplifier. It is a push-pull type, adapted to work with the Sanborn galvanometer. It is highly insensitive to a-c interference because of the large amount of in-phase degeneration provided by the large cathode resistors.

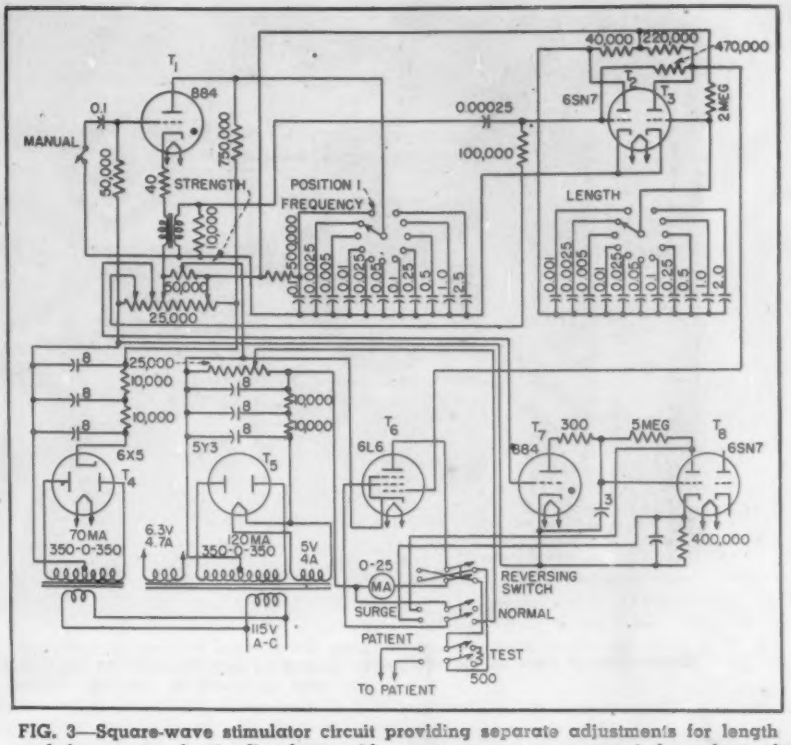

FIG. 3—Square-wave stimulator circuit providing separate adjustments for length and frequency of stimuli, along with constant preset current independent of resistance of patient

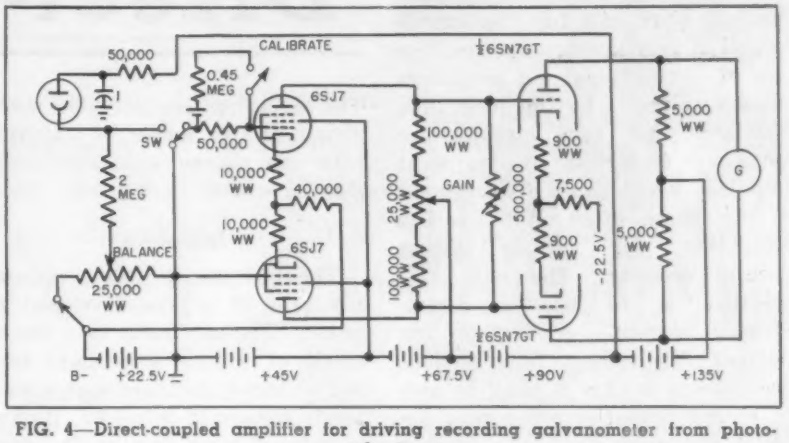

FIG. 4—Direct-coupled amplifier for driving recording galvanometer from phototube input

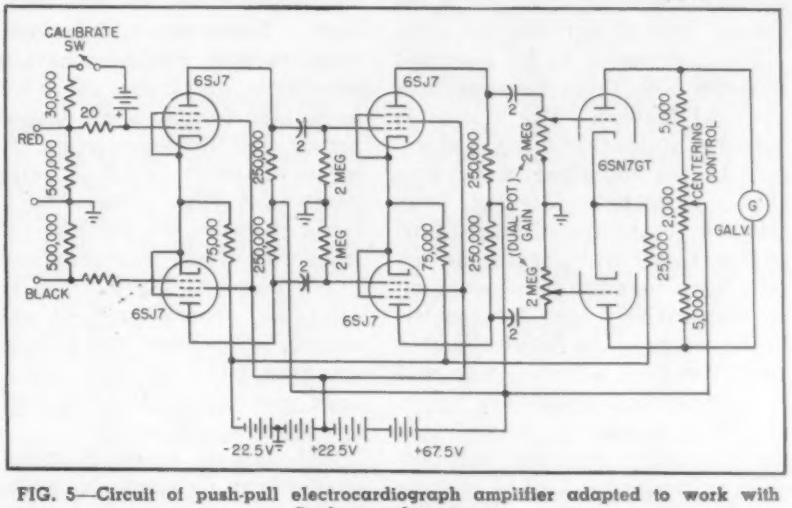

FIG. 5—Circuit of push-pull electrocardiograph amplifier adapted to work with Sanborn galvanometer

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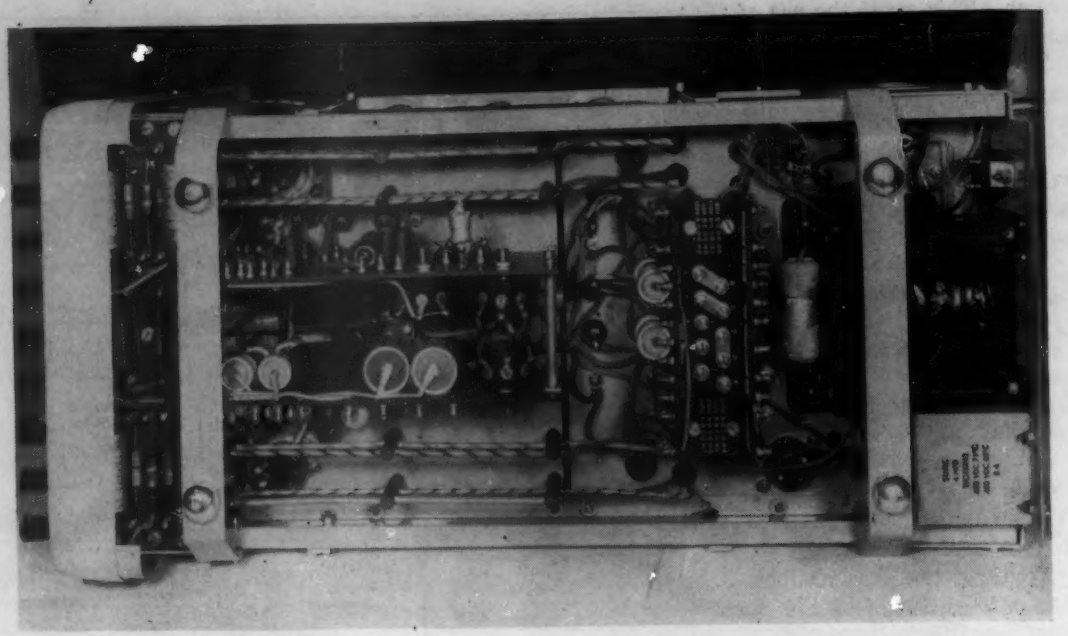


Under-chassis view of the oscilloscope showing preset amplifier controls (left of center) and spaced leads from front terminals to deflector plates

Direct-Coupled

THE requirements of modern servo technique and electromedical work call for the examination of very low frequencies. The use of conventional a-c amplifiers involves circuits having long time constants, but such circuits are seriously disturbed by transient impulses, which cause displacement of the image, often off the screen altogether, for periods lasting several seconds. The only real solution is to use a direct-coupled system. A further important requirement in a modern oscilloscope is that it shall be able to record potential differences between two points in a network, but should disregard fluctuations in the general level of network potential.

The instrument to be described achieves both these features in a practical fashion. The system is indeed so stable that it is not necessary to use stabilized power supplies. Although attention was primarily concentrated on the lower-frequency requirements, the circuits were found to be effective up to comparatively high frequencies. In the design of the finished instrument, therefore, attention was paid to constructional details and layout in such a manner as to maintain the frequency response substantially uniform up to 1 mc or, at some sacrifice of sensitivity, up to 3 mc. The amplifiers are provided with a simple link by means of which the user can choose whichever condition he wishes.

Special CRT

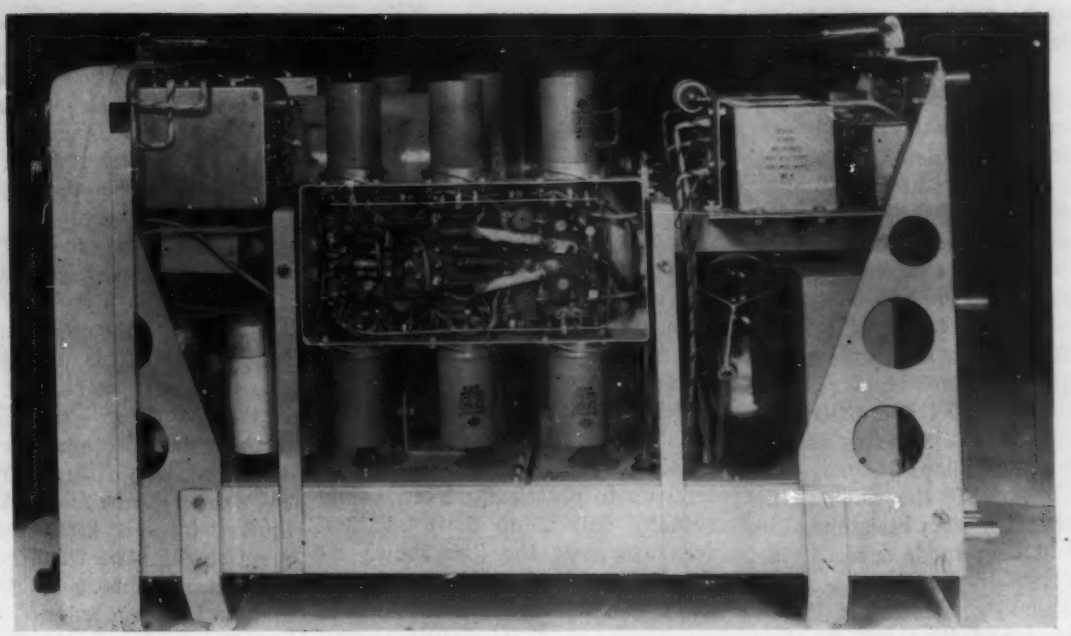
The instrument uses a cathode-ray tube of a type developed for radar. The particular tube has the merit of giving a brilliant trace and a sharply focussed spot with an anode voltage of only 1 kv. Because of this relatively low anode voltage the sensitivity of the tube itself is high. Electrostatic deflection is used, vertical deflectors having a sensitivity of 2.2 mm per v while horizontal deflectors are approximately half this sensitivity. The screen diameter is 3.5 in. with a nearly flat face. Four standard types of screen are available; blue trace with afterglow approximately 1 microsecond; green trace with afterglow approximately 1 millisecond; yellow trace with afterglow approximately 6 seconds; and blue trace with yellow afterglow lasting approximately 20 seconds.

Although the screen diameter is smaller than on many oscilloscopes the extremely small spot diameter (approximately 0.25 mm) at full brilliance results in such sharp traces that the effectiveness of the display is better than on many larger diameter screens.

The c-r tube sensitivity permits a high amplifier sensitivity to be obtained with a maximum gain of only 700. This condition results in a screen deflection of 1.5 mm per mv rms input to the amplifier. The sensitivity on the horizontal amplifier is only about half this figure.

The focus and intensity controls are independent and the focus is sharp over the whole screen. This effect is accomplished by the manner of connecting the deflector plates to the amplifying network, which ensures that the mean deflector potential is the same as the final anode voltage of the cathode-ray tube. This requirement is critical and provision for adjustment is explained later.

The two amplifiers, which are identical in all but minor particulars, each consist of three pairs of symmetrically arranged push-pull tubes. The basic circuit is shown in Fig. 1. The tubes V_1 and V_2 constitute a symmetrical cathode fol-



Side view of oscilloscope showing X-amplifier suspended from shock mounts. An identical 6-tube amplifier is suspended on other side of chassis

Oscilloscope

Examination of low-frequency phenomena encountered in servo techniques and electromedical work requires a high-sensitivity oscilloscope employing d-c amplifiers. Design considerations are given for a portable device useful in observation of waveforms up to 3 megacycles

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lower or "long-tailed pair". The anodes of the tubes are directly coupled to the grids of tubes V_3 and V_4 which are a similar long-tailed pair arrangement, and these anodes are again coupled directly through the grids of the final pair, which are simple separate cathode-follower stages, the voltage across the cathode resistors being fed direct to the deflector plates of the cathode-ray tube.

All three pairs of tubes are fed from the same supply line but the circuit is so arranged that the cathodes of the first pair are at a low potential, those of the second pair are at an intermediate potential, while in the third pair the whole of the signal voltage is developed in the cathode circuit, there being no anode resistor in either tube.

This symmetrical arrangement provides not only the discrimination previously mentioned but also contributes to the stability because there is no signal current in the B+ line. A symmetrically-applied signal to the input causes circulating currents around the network $V_1R_1R_2V_2$ and there is no signal current either in the high-voltage line or in the cathode resistor. The cathode resistor thus has no effect on the amplification for symmetrical signals, but to any asymmetrical signal it becomes operative and introduces heavy negative feedback; the resulting discrimination in the actual amplifiers is of the order of 1,000 to 1 at the maximum gain setting.

A similar action takes place in the second and third pair of tubes, though advantage of the symmetry here is more in the avoidance of signal currents in the B+ line, since these are now of greater magnitude. Because of this circuiting there is no interaction between one stage and the next or between one amplifier and the other and since, as will be seen later, the time base is operated on a similar principle, the whole instrument can be fed from a common power supply without any appreciable interaction among the circuits.

Since the whole network is directly coupled it operates from zero frequency upwards. Small corrector chokes are included in the anode circuit, so proportioned as to maintain the response level until

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the cutoff point is reached after which rapid attenuation sets in.

Functional Controls

Figure 2 shows the amplifier network in greater detail. Variation in the sensitivity of the amplifier is accomplished by providing separate cathode resistors for the first two tubes and bridging the cathodes with a variable resistance. When this resistance is zero, so that the cathodes are connected together, the two cathode resistors operate in parallel and the circuit is effectively the same as that of Fig. 1 and develops its maximum gain. Increasing the value of the gain control inserts resistance into the circulating anode current ring, the voltage drop acting to oppose the push-pull component of the input signal and thus reducing the push-pull sensitivity of the stage. The push-push sensitivity is not affected and therefore the discrimination tends to fall off as the gain is reduced, but since maximum discrimination is required at maximum sensitivity this constitutes no serious disadvantage in actual practice.

The actual voltage on the anode of the tubes V_1 and V_2 is determined mainly by the voltage drop in the anode resisters R_1 and R_2. An additional source of voltage, however, is applied to these two anodes through a symmetrical network from another source, actually taken from the power supply unit a little earlier in the smoothing chain. This voltage is fed through buffer resistors having a high value compared with the anode resistors, so that the amplification of the network is not appreciably affected. It will be noted, however, that the potential is actually introduced via the slider of potentiometer P_1. At the midpoint of this potentiometer, the potential applied to each tube is the same, but as the slider is moved a condition of unbalance is introduced, which has the effect of making one anode slightly more positive and the other slightly more negative. This unbalance is transferred through the next two pairs of tubes and produces a shift of the spot on the cathode-ray tube screen irrespective of any movement which is being produced by the signal. A smooth and wide range of control is obtained by this means, the important feature being that the change of position is instantaneous so that the location of the image is both positive and rapid.

Bandwidth Adjustment

It has already been mentioned that at the option of the user the frequency response can be varied from 1 to 3 mc. The adjustment is accomplished in the second pair of tubes, the anode resistors for which are in two portions. When both portions are in operation the amplifier maintains its response level up to practically 1 mc, being actually only 3 db down at this frequency. If the link shown in the diagram is closed, however, the upper portions of the two anode resistors are short-circuited and only the lower portions are effective. Under these conditions the frequency response is maintained up to 3 mc but the gain of the stage is reduced by approximately three times. From the symmetry of the arrangement it will be seen that the link short-circuits two points at the same d-c potential so that no circulating currents result.

Figure 3 shows the performance of the amplifier with the link in the 3 mc position. It will be observed that the response is completely uniform from zero up to a frequency very close to the cutoff frequency, after which rapid attenuation occurs. There is no phase shift in the lower frequency portions but some phase shift becomes noticeable a little above 500 kc and the phase angle is approximately 75 deg at 3 mc. Because of this phase shift at the limiting frequency the locus of the operating point on the tube characteristics at this point is no longer a straight line but is an ellipse of fairly large eccentricity. Consequently the volt-ampere requirements are considerably greater than at the lower frequencies where there is no phase shift.

Because of this fact it is not possible to develop the full screen deflection at the highest frequencies and at 3 mc the maximum deflection obtainable is a little over 2 cm. The position rapidly improves as the frequency is reduced. About double this deflection is available at 1.5 mc and at a little under 1 mc the full screen can be filled. While this limitation might appear serious, in practice the need for a good high-frequency response is determined mainly by the need to handle the harmonics of a fundamental operating on a much lower frequency. The relative strength of these harmonics will, in any case, be small so that not more than about 10 percent of the screen will be required. Actually, approximately 25 percent of the screen can be filled even at the highest frequency and this amount is considered satisfactory.

Current-Forcing Circuit

In order to obtain the discrimination required in the input stage it is necessary that the cathode resistors of V_1 and V_2 shall be of high value. This would normally result in the cathode potential being appreciably positive to ground, so that if the grids on the first stage are operating near ground potential they would be so negative with respect to the cathode as to reduce seriously the effective conductance of the tubes V_1 and V_2. It is, therefore, necessary to maintain the

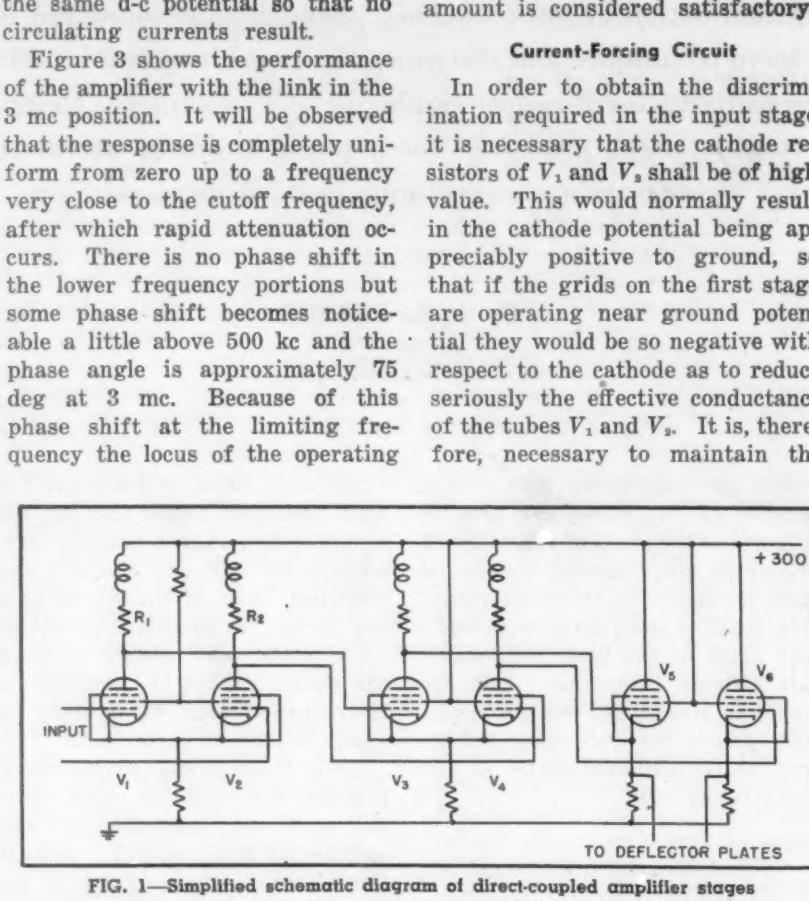

FIG. 1—Simplified schematic diagram of direct-coupled amplifier stages

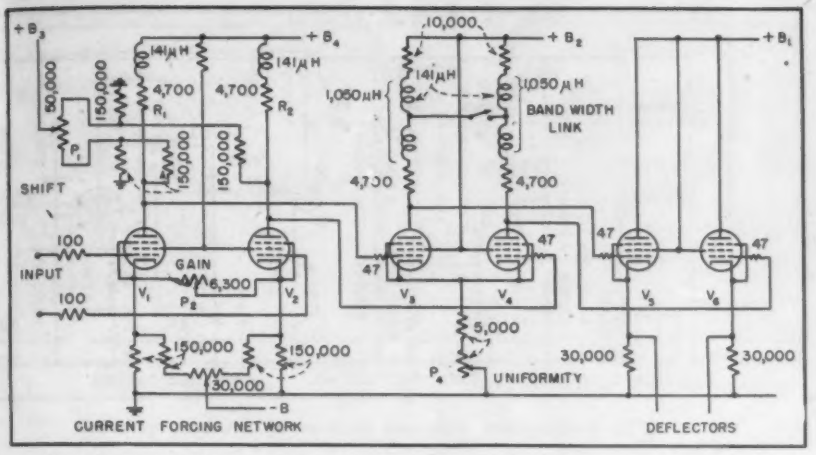

FIG. 2—Detailed circuit schematic of direct-coupled amplifier showing controls

anode current through V_1 and V_2 at a suitable value, and in order to accomplish this current is forced through the cathode resistors from a negative source of current. This supply is effectively a constant-current supply and forces into the network a current which divides equally through the two cathode resistors. The current is actually fed through the slider of a potentiometer. When the instrument is set up the slider is adjusted until the potential of the two cathodes, with the gain control at the maximum resistance, is equal. Without this adjustment operation of the gain control would produce a disturbance in the datum anode current that would be indistinguishable from a genuine signal.

To maintain sharp focus and freedom from astigmatism the final anode of the the cathode-ray tube must be at the same potential as the mean potential of both pairs of deflector plates. To achieve this condition the final anode of the cathode-ray tube is not solidly grounded but is connected to each of the four deflector plates through four equal resistors of 0.1 megohm as shown in Fig. 4. The mean outputs of the two amplifiers are then equated by appropriate adjustment of the anode current of the second stage in the amplifier at P_4. (Fig. 2). This adjustment is necessary on but one amplifier and is therefore incorporated in the horizontal amplifier only.

Time Base

A symmetrical construction is adopted in the time base which is shown in simplified form in Fig. 5. The capacitor C is charged through the pentode tube V_8. Across the capacitor is the discharge tube V_7, the grid of which is held at a potential determined by the network B, V_9 and D. When the capacitor C is discharged, the cathode of V_7 is near the B+ potential so that the grid of the tube is considerably negative with respect to the cathode and the tube is non-conducting. As the capacitor charges up, the cathode potential falls until it becomes only slightly positive with respect to the grid and the tube commences to conduct. As soon as current flows in this circuit a potential is developed across A which reduces the screen potential of V_9, causing a rise in anode potential which makes the grid of V_7 more positive. This change increases the conductance of V_7 so that the discharge is accelerated and a rapid flyback is obtained.

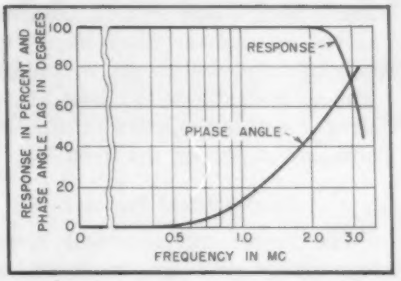

FIG. 3—Frequency response and phase angle of amplifier with link adjusted for 3-mc band

The action of V_7 and V_9 results in an effective transfer of the cathode current of V_9 from the anode to the screen so that the total drain from the supply line remains constant. This is an important feature since it not only avoids interaction between the time base and the amplifiers but it also renders the operation of the time-base circuit independent of the time-constant of the high voltage supply line. Because of this condition the circuit continues to function satisfactorily down to indefinitely low frequencies. Capacitor C is actually a series of eight of gradually increasing value in order to give discrete ranges of frequency, and for the sake of reasonable portability the largest capacitor is such as to provide a minimum sweep frequency of 2 cps. A two-pin socket is provided, however, to make the time-base voltage available externally, or for single-sweep operation as explained below. Additional capacitors can be added across the socket to extend the time base frequency downwards to at least to 0.2 cps.

Fine control of the frequency is obtained by varying the current through the pentode tube V_8 via the grid potential. The voltage across the time-base capacitor is transferred through a high-resistance potentiometer to the input of the horizontal amplifier. This arrangement permits the width of the scan on the cathode-ray tube screen to be varied from about one half to five screen diameters. The highest time-base frequency is 150 kc and since the horizontal amplifier frequency response extends to at least ten times this value the saw-tooth waveform is satisfactorily maintained throughout the full frequency range. The potentiometer is compensated for stray capacitances so that the correct ratio is maintained throughout the full frequency range. To offset the d-c component of the time base signal the other X-amplifier input terminal is supplied with a steady voltage adjusted by the potentiometer P_5 to equal the mean d-c value of the signal.

Synchronism

The synchronism is automatic. Synchronizing signals are applied through the tube V_{10} to the grid of tube V_9. These signals control the current of V_9 and hence the grid potential of V_7. A positive synchronizing impulse will thus drive

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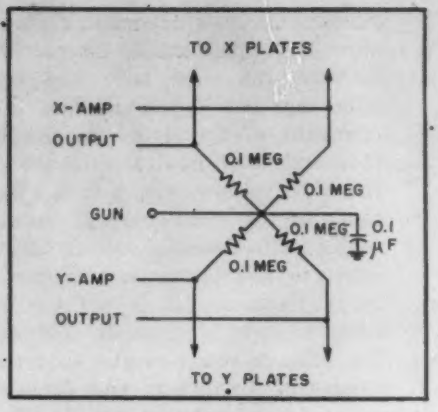

FIG. 4—Gun and deflector plate hookup

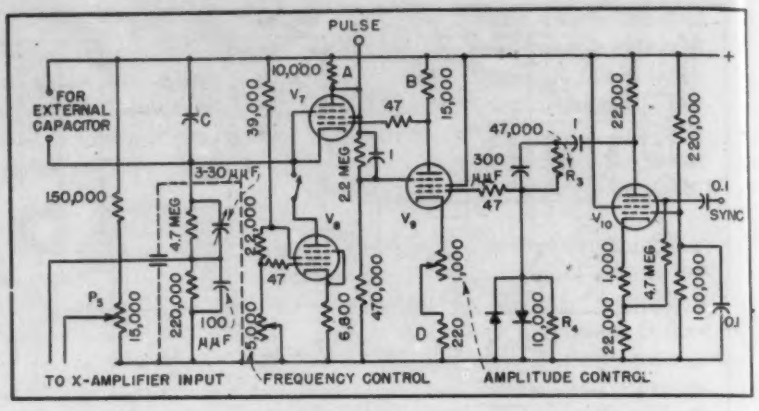

FIG. 5—Simplified schematic diagram of time base generator

the grid of V_7 positive and initiate the discharge.

The pulse of current through V_{10} does produce some slight modulation of the high voltage line but this is limited by the rectifier network in the bottom half of the potentiometer which transfers the voltage from V_{10} to V_9, and also by the inclusion of a high value of resistance in the cathode. As a result, the current of V_{10} is, in practice, substantially constant.

The main function of the two rectifiers just mentioned, however, is to limit the synchronizing pulse to a suitable value. The resistors R_3 and R_4 are so chosen that for small signals the rectifiers are of relatively high resistance. As the voltage on R_4 rises, however, the rectifiers begin to conduct and thus to shunt the bottom half of the potentiometer and limit the voltage applied to V_9. It is thus not possible to produce over-synchronism with consequent shortening of the time-base sweep. This feature is valuable in practice because with conventional methods a change in amplitude of the signal under examination causes a change in the point at which the time base triggers, with consequent unsteadiness of the image. With the present arrangement the image remains quite steady, irrespective of the changes of amplitude and the arrangement is so successful in practice that no synchronizing control is provided. It is merely necessary to apply to the sync terminal a signal either from the output of the vertical amplifier or direct from some part of the circuit under examination.

The negative pulse developed across A is brought to a terminal at the rear of the instrument and may be connected to the modulator grid on the cathode-ray tube, if desired. In this condition the spot is blacked out during the flyback.

Constructional Features

The power supplies and time-base components are mounted on the main chassis while the two amplifiers, which are assembled as separate units, are mounted in antivibration mountings on either side of the cathode-ray tube. All main controls are available on the front panel. The four deflector plates are connected to terminals along the bottom of the front panel and four switches immediately above permit each plate individually to be connected to ground, to the terminal either directly or through a capacitor, or to the output of the appropriate amplifier. The leads to the deflector plates are spaced from each other and from the chassis in order to reduce the stray capacitance. Where minimum plate capacitance is essential, however, connections can be made to four terminals at the back of the instrument. These terminals are normally strapped to adjacent terminals connected to the front terminals but by opening the links the additional capacitance of the wiring is removed. The gun and modulator electrodes are also accessible at the rear, together with the pulse output for flyback suppression.

Symmetrical input is provided on each amplifier with a ground terminal in between and each input is provided with a multiposition switch. This switch allows direct connection; direct connection through a resistance attenuator that reduces the sensitivity approximately fourteen times; and direct or attenuator connections including an isolating capacitor of 0.1 microfarad with 1.2 megohms to ground.

The horizontal amplifier switching has two additional positions. The first of these connects the amplifier input to the time base while the second is for single-sweep operation, the time base still being connected but the discharge tube rendered inoperative.

The single sweep referred to is not electronic in character. The time-base controls are set to operate at the required sweep speed and the time-base terminals are then short-circuited externally. On removal of the short-circuit the spot will sweep across the screen and will stay in its final position until restored by re-imposing the short-circuit across the capacitor. The d-c positioning of the spot and the gain control of the horizontal amplifier can be manipulated to include the whole of the sweep on the screen or any portions thereof. The internal time base is rendered inoperative when the amplifier is connected for external signals.

A graticule with millimeter rulings is located in front of the tube face, being held in position by a cover plate which incorporates a telescopic light shield. This cover plate can be removed completely and replaced by a camera, either for single shots or for continuous recording.

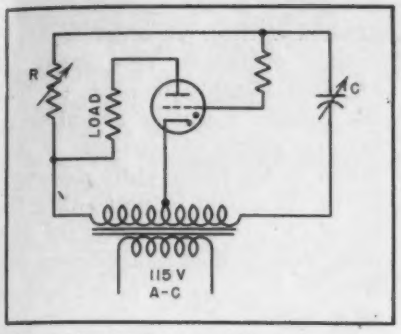

FIG. 1—Basic phase-control circuit using a single thyratron tube

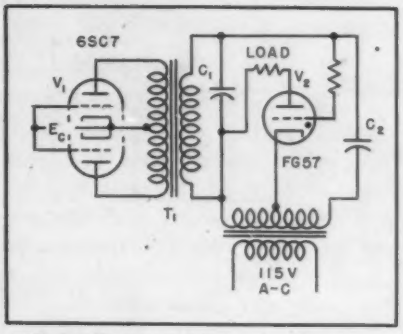

FIG. 2—Phase-control circuit with vacuum tubes as the variable parameter

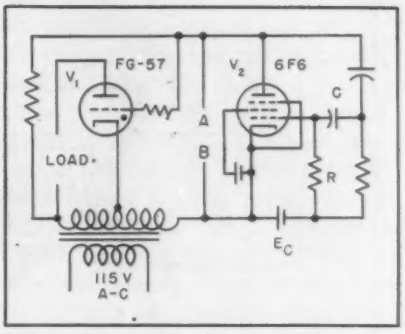

FIG. 3—Reactance-tube phase-control circuit that eliminates the transformer

Thyratron Phase-Control Circuits

Principles of operation, characteristics, applications and relative merits of several electronic circuits for controlling a large direct current by means of a small change of voltage

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NEED occasionally arises for a device to control a relatively large direct current by a small change of direct voltage. This result can be accomplished by incorporating one or more high-vacuum tubes in a thyratron phase-control circuit, as first suggested by Baker, Fitzgerald, and Whitney.[1]

Figure 1 shows the basic form of a commonly used phase-control circuit, in which the average anode current of the thyratron can be varied gradually from zero to its maximum value by changing the value of C or R and thus varying the phase of the grid voltage relative to the anode voltage.[2] The circuit can be controlled by means of direct voltage if the resistor R is replaced by two high-vacuum triodes, connected to the circuit through a transformer, as shown in Fig. 2.

A circuit of the form of Fig. 2 transfers the dynamic plate resistance of a vacuum tube into the phase-control circuit, and the magnitude of the transferred resistance is varied by adjusting the direct bias on the control tube. The vector diagram for this type of phase-control circuit is slightly different from that of the basic circuit of Fig. 1 because of the fact that the power factor of the varying parameter, as well as its magnitude, changes.

When the control tube is biased beyond cutoff, the inductance of the primary of the coupling transformer T_1 appears in the phase-control circuit.

At the other extreme, and with zero bias on the control tube, a relatively low resistance is transferred into the phase-control circuit. This situation is also complicated by the leakage reactance and internal resistance of the transformer. Thus, the vector diagram will not be of the circle type, as it is in the circuit of Fig. 1, in which the effective value of the alternating grid voltage is constant. This constant value is not a necessary condition, however, as long as the smallest value of the peak of the wave is always considerably larger than the critical grid voltage for the tube at the particular value of plate voltage used.

Range of Control

Control over almost 180 degrees may be gained by careful adjustment of circuit constants. It is advisable to adjust C_1 and C_2 by using decade capacitors. The main disadvantage of this circuit is that an expensive interstage transformer seems to be necessary to insure the

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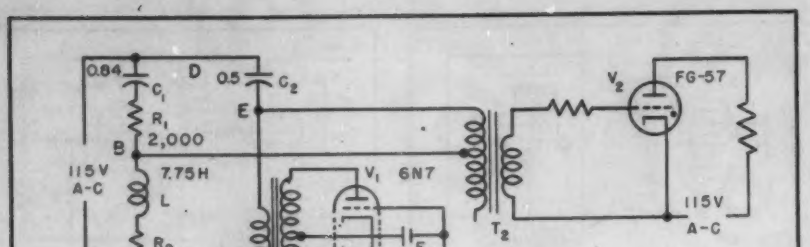

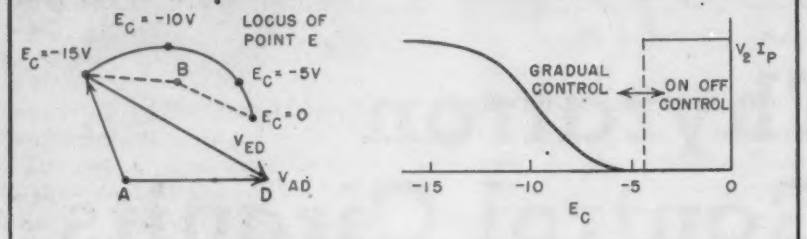

FIG. 4—Circuit for phase control with direct voltage. Transformer T_1 is a Stancor A-63C, and T_2 is a Thordarson T-33A91. Internal resistance R_2 is 75 ohms. Vector relations and control characteristics are included

desired change in effective transferred impedance for gradual control over the complete 180 degrees of positive thyratron plate voltage. Moreover, when bias E_c is zero, the resistance of the 6SC7 control tube is not so low as might be expected, because under this condition the alternating voltage fed into the 6SC7 plate circuit is low and thus the region of operation on the plate characteristic is such as not to favor low dynamic plate resistance.

If on-off control[3] is desired, the choice of coupling transformers is not at all critical.

The need for an expensive coupling transformer could be avoided by using the reactance-tube circuit shown in Fig. 3. In this circuit the 6F6 is operated in such a manner that it presents a capacitive reactance across points A and B. The shunt conductance is reduced to zero by proper choice of R and C. This circuit gave about 90 degrees of control of FG-57 current as a function of 6F6 control-grid bias.

The main difficulty seemed to lie in the fact that the alternating voltage fed into the reactance-tube circuit from the phase-control circuit varied considerably in magnitude and also was hard to keep undistorted. This circuit has the additional disadvantage that it requires a d-c supply for the reactance tube.

Use of Network

The need of the expensive coupling transformer in the circuit of Fig. 2, or of the d-c power supply in that of Fig. 3, was avoided by using the network and circuit of Fig. 4. Here the quality of the thyratron grid transformer T_2 is not important. Even the least expensive of the transformers tried worked well. It is desirable, however, that the transformer present as high an impedance as possible to the network and still provide a satisfactory magnitude of voltage to the thyratron grid. The transformer T_1 between the network and the 6N7 control tube is not at all critical.

The operation of the circuit depends on the fact that the potential of point E, with respect to point A, moves as shown in the vector diagram as the 6N7 bias is varied. If the values of R_1, R_2, L, and C_1 are adjusted in such a manner that the potential of point B lies as shown in the vector diagram, the voltage V_{BB} will swing more than 180 degrees. This voltage is fed into the thyratron circuit through the thytron grid transformer.

It may be necessary to reverse the secondary leads of T_2 to obtain the proper phase relationship for gradual control. In order to avoid erratic operation, care must be taken in locating point B so that the voltage V_{BB} does not undergo extreme amplitude changes in addition to the phase shift discussed above. It should be noted that the voltage V_{AB} that is fed into the 6N7 plate circuit does not become extremely small as E_c is reduced to zero.

Control characteristics are also shown in Fig. 4.

Wider Range

Bancroft[3] describes a method of obtaining control over 90 degrees of the plate voltage cycle by adding an alternating voltage, whose magnitude can be controlled, to a fixed alternating voltage which has a 90-degree relationship to the variable

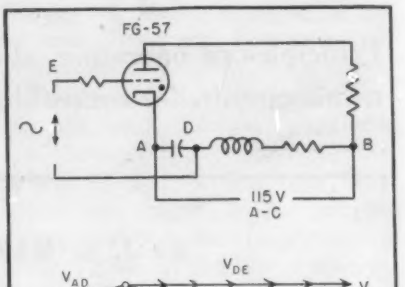

FIG. 5—Control is effected by changing the amplitude of an alternating voltage

voltage. Thus the resultant voltage varies essentially 90 degrees in phase as the magnitude of the variable voltage is raised from zero to a value considerably larger than the fixed voltage. An extension of this method allows control over 180 degrees or, if two thyratrons are used, over 360 degrees.

Figure 5 shows the basic circuit and the manner in which the phase of the grid voltage varies. The voltage V_{AD} must keep the thyratron from firing when V_{DE} is zero and must have enough vertical component to prevent erratic behavior when V_{AB} has its minimum effective value. The vector diagram shows that the alternating grid voltage V_{AB} swings from almost 180 degrees lagging to almost an in-phase position with respect to a horizontal reference. Control over the complete 180 degrees of positive half

cycle of plate voltage is obtained.

Figure 6 shows a form of the circuit of Fig. 5 in which the magnitude of voltage V_{DS} is varied by changing a direct voltage. The plate of the 6J5 is fed with raw a-c and T_1 is tuned to select the 60-cycle component. If the cost and space requirements do not prevent, the circuit can be made less critical as to circuit constants by the addition of a d-c plate supply in the circuit of V_1.

Complete Cycle

Figure 7 shows an interesting circuit which might have advantages in certain applications where control is desired over the complete 360 degrees. Individual thyratron current waves forms and the control curve are also shown. The circuit, in the form shown, may be used only when the flow of two or three milliamperes of 6N7 grid current is not objectionable.

Magnetron Flux Control

During a recent investigation it became desirable to limit surges in magnetron plate current and to control backheating. In this application, the drop across a resistor in the magnetron plate circuit serves as the bias on the control tube, which in turn shifts the phase of the voltage on the grid of the thyratron and thus controls the power delivered to the magnetron filament.

The circuits discussed here can be used to stabilize magnetron current more directly without relying on control of filament current. This can be accomplished by supplying the axial magnetron flux by means of electromagnets that are fed by thyratrons controlled, through the network of Fig. 4, by the magnetron direct plate current. The output of the thyratron must be filtered to reduce the ripple.

The circuit of Fig. 8 was found to deliver almost pure direct current to the field coils. Capacitor C and inductor L form a smoothing filter to eliminate ripple. The function of V_3, which is operated essentially as a diode, is to enable the coil current to continue after the instant in the cycle at which the main thyratron is extinguished. The action of the circuit is such that if, for any reason, the plate current of the magnetron tends to increase, the direct bias on the control tube is changed so as to cause the thyratron alternating grid voltage to be shifted in such a direction that the average magnet current, and thus the flux density, is automatically increased. The magnetron will therefore experience a smaller increase in plate current.

Only a few of the practical applications of these circuits have been outlined. Although the gradual type of control has been emphasized in this paper, the circuits lend themselves to on-off control, which may be equally important in industrial applications.

The work that forms the basis of this paper was done in conjunction with a research project on magnetrons sponsored by the Office of Naval Research.

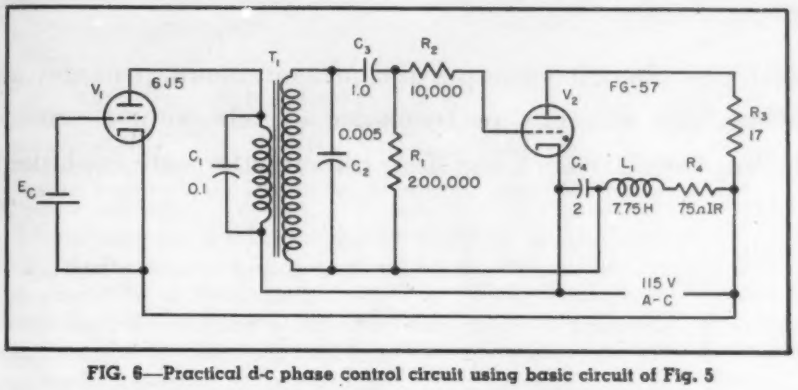

FIG. 6—Practical d-c phase control circuit using basic circuit of Fig. 5

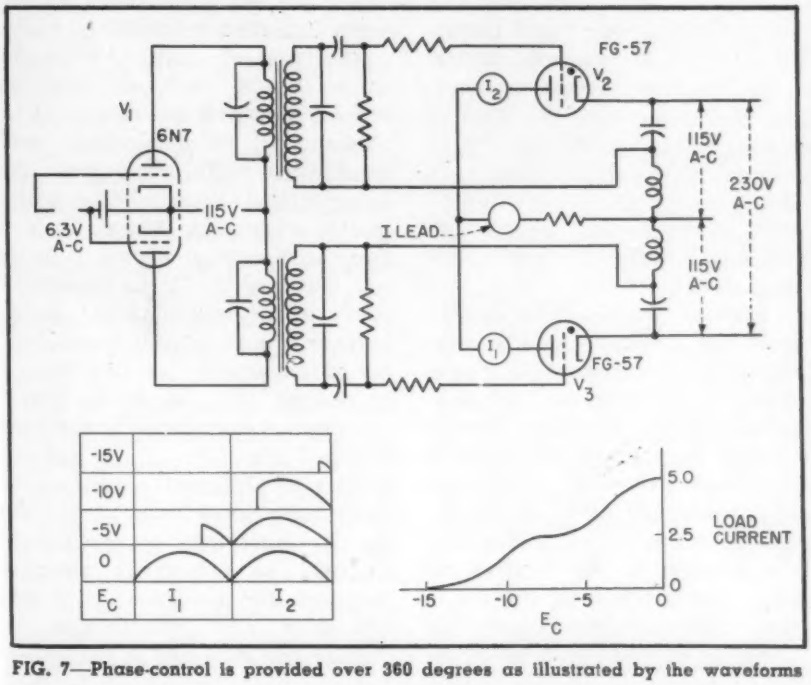

FIG. 7—Phase-control is provided over 360 degrees as illustrated by the waveforms

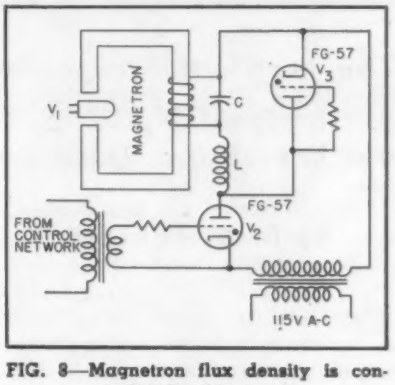

FIG. 8—Magnetron flux density is controlled by this circuit

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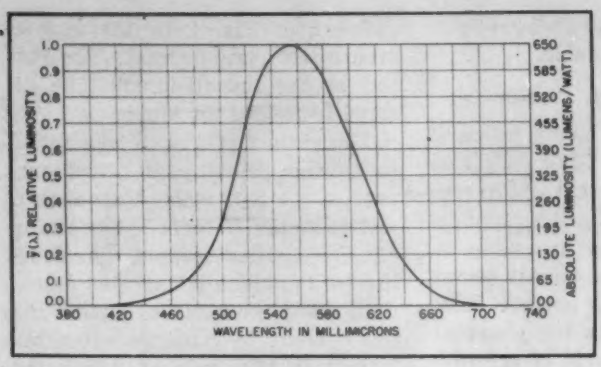

FIG. 1—Relative values (left) of luminosity curve apply to conditions met in television; absolute values (right) are used to determine luminous efficiency

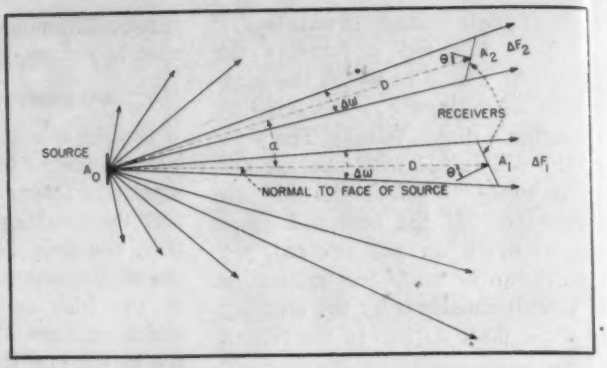

FIG. 2—Luminous intensity of the source is the flux emitted per solid angle. Illuminance of a receiver is the flux per unit area incident on its surface

PHOTOMETRY in Television Engineering

This introduction to fundamental photometric concepts and measurements provides an understanding of principles and methods whereby performance of television receivers may be evaluated. Quantities needing measurement and their interrelations are explained

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PHOTOMETRY is of considerable interest to television engineers because the engineering evaluation of television receivers depends to an important extent on photometric measurements. By making these measurements television engineers can accumulate objective data on the distribution of light output over the picture plane on which to base future designs of receivers.

Receiver Performance

Among the factors affecting receiver performance and in which photometry plays an important role are: (1) highlight brightness, (2) brightness range or large area contrast, (3) brightness gradation or gamma, (4) detail contrast, resolution contrast or sharpness, (5) ambient illumination, (6) directional characteristic of the emission, and (7) such other effects on the photometric performance of the receiver as hum and flicker. Although the relative importance of these factors for viewer satisfaction is determined essentially by experience in the field, it is only by possessing photometric data on them that this experience can be converted into specifications.

Photometry is concerned not only with the measurement and computation of the energy relationships in the emission process, propagation, absorption and reflection of radiant energy in the wavelength range of 380 to 765 millimicrons, but also with the quantitative evaluation of this radiant energy with respect to its capacity to stimulate visual sensations.

A luminosity curve shows as ordinates the relative effectiveness (plotted as the reciprocal of the required radiant energy) of various wavelengths of radiant energy to evoke, for a particular observer and under particular conditions, visual sensations of equal brightness. A luminosity curve may thus be considered as the relative response characteristic of the eye.

The difficulties encountered in attempting to make photometry an objective science are that the relative response characteristic of a given individual is different for different conditions of observation and that the relative response characteristics of different observers, under the same conditions of observation, are not identical.

The use of many luminosity curves would, obviously, lead to endless confusion and ambiguity in photometric measurements and specification. To avoid this, the International Commission on Illumination adopted in 1924 a standard luminosity curve. Figure 1 shows the standard I. C. I. luminosity curve which was obtained as an average of a reasonably large number of luminosity curves. It should be realized, that, (because a different average curve would have been obtained if a different group of observers or different conditions of observation have been used), the standard-luminosity curve is essentially an arbitrarily assumed standard for purposes of standardization and specification of photometric data and is not neces-

Table I—Standard Luminosity Function

λ in mμ	$\bar{y}(\lambda)$	λ in mμ	$\bar{y}(\lambda)$	λ in mμ	$\bar{y}(\lambda)$	y in mλ	$\bar{y}(\lambda)$
380	0.0000	480	0.1390	580	0.8700	680	0.0170
385	0.0001	485	0.1693	585	0.8163	685	0.0119
390	0.0001	490	0.2080	590	0.7570	690	0.0082
395	0.0002	495	0.2586	595	0.6949	695	0.0057
400	0.0004	500	0.3230	600	0.6310	700	0.0041
405	0.0006	505	0.4073	605	0.5668	705	0.0029
410	0.0012	510	0.5030	610	0.5030	710	0.0021
415	0.0022	515	0.6082	615	0.4412	715	0.0015
420	0.0040	520	0.7100	620	0.3810	720	0.0010
425	0.0073	525	0.7932	625	0.3210	725	0.0007
430	0.0116	530	0.8620	630	0.2650	730	0.0055
435	0.0168	535	0.9149	635	0.2170	735	0.0004
440	0.0230	540	0.9540	640	0.1750	740	0.0003
445	0.0298	545	0.9803	645	0.1382	745	0.0002
450	0.0380	550	0.9950	650	0.1070	750	0.0001
455	0.0480	555	1.0002	655	0.0816	755	0.0001
460	0.0600	560	0.9950	660	0.0610	760	0.0001
465	0.0739	565	0.9786	665	0.0446	765	0.0000
470	0.0910	570	0.9520	670	0.0320		
475	0.1126	575	0.9154	675	0.0232		

The commonly used units of wavelength are the micron (μ) = 10^{-6}meter, the millimicron (mμ) = 10^{-9}meter, and the Angstrom unit (A) = 10^{-10}meter.

Table II—Nomenclature and Symbols Used in Photometry

RADIOMETRY			PHOTOMETRY		
Name	Symbol	Unit MKS	Name	Symbol	Unit MKS
Radiant Energy	U	joule	Luminous Energy	Q	talbot
Radiant Flux	P	watt	Luminous Flux	F	lumen
Radiant Emittance	W	watt/m²	Luminous Emittance	L	lumen/m²
Radiant Intensity	J	watt/ω	Luminous Intensity	I	lumen/ω(candle)
Radiance	N	watt/ωm²	Luminance	B	lumen/ωm² (candle/m²)
Irradiance	H	watt/m²	Illuminance	E	lumen/m² (lux)
	m	meter		w	steradian

sarily the response of any normal or average individual. Table I gives the standard luminosity function, $\bar{y}(\lambda)$, at 5 millimicron steps.

Units of Photometry

Photometry has been complicated by nomenclature and systems of units. To alleviate this situation, the committee on Colorimetry of the Optical Society of America has recommended Table II, which gives the names, symbols, and basic mks units of radiometry and photometry. The term luminance in Table II replaces the older term brightness, which led to the confusion between the objective concept of brightness as a measurable quantity and the subjective concept of brightness which refers to the sensation in the consciousness of the human observer. It is recommended that the term brightness be used only in the latter sense.

Any radiometric unit in Table II is converted into the corresponding photometric unit by evaluating it with respect to the standard luminosity function $\bar{y}(\lambda)$. Thus, if $P(\lambda)$ be radiant flux (in watts per millimicron) distributed over the continuous spectrum extending between λ_1 and λ_2, then the luminous flux in lumens is given by

$$F = 650 \int_{\lambda_1}^{\lambda_2} P(\lambda)\, \bar{y}(\lambda)\, d\lambda \qquad (1)$$

where λ is measured in millimicrons. The ratio of any photometric quantity to the corresponding radiometric quantity in Table II is defined by the ratio

$$K = 650 \frac{\int_{\lambda_1}^{\lambda_2} P(\lambda)\bar{y}(\lambda)d\lambda}{\int_{\lambda_1}^{\lambda_2} P(\lambda)d\lambda} \quad \text{lumens per watt} \qquad (2)$$

and is called the absolute luminosity or luminous efficiency (expressed in lumens per watt) of the radiant energy. Thus one watt of monochromatic radiant flux of wavelength 555 mμ (peak of standard luminosity curve) is equivalent to 650 lumens, whereas one watt at 500 mμ is equivalent to 0.323 × 650 = 210 lumens. (The value of 650 lumens per watt has been adopted by the committee on Nomenclature and Standards of the Illuminating Society of America. However, as soon as the new proposed international photometric standard is adopted, this value will probably increase to 685 lumens per watt.

Luminous efficiency K should not be confused with the efficiency of a practical light source, which is the ratio of the total luminous flux to the total power input. The efficiency of a light source is less than K since generally only a fraction of the power input is converted into radiant flux.

Calculations

Referring to Fig. 2, let the small plane source of area A_0 emit P watts or $F = 650 \int_0^\infty \bar{y}(\lambda) P(\lambda)\, d\lambda$ lumens, and let A_1 and A_2 be the areas of two small receivers which subtend the same solid angle $\Delta\omega$ at the center of the source and are located at the same distance D from it. The luminous intensity or candlepower of a source is given by

$$I = \Delta F/\Delta\omega \qquad (3)$$

and is measured in candles or lumens per steradian. The number of lumens ΔF_1 and ΔF_2 contained in the solid angles $\Delta\omega$ will, in general, be different. Thus the intensity $I_1 = \Delta F_1/\Delta\omega$ measured in the direction normal to the source is different from the intensity $I_2 = \Delta F_2/\Delta\omega$ measured along a direction making the angle α with the normal. In specifying the intensity or candlepower of a source, it is therefore necessary to state the direction in which the intensity is measured or preferably to give a candlepower distribution curve. The directional characteristic of many extended sources, such as a luminescent screen of a cathode-ray tube, obey Lambert's law which states that

$$I_2 = I_0 \cos\alpha \qquad (4)$$

In the case of a uniform point or

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spherical source, the intensity is independent of direction and is equal to $F/4\pi$. Table III shows the relationship between the three most frequently used units of intensity.

A surface of area ΔA placed in a field of flux F is said to be illuminated with the illuminance in lumens per square meter (in mks units) of

$$E = \Delta F/\Delta A \quad (5)$$

where ΔF is the flux incident on the surface. The illuminance of receiver ΔA_1 (Fig. 2) is

$$E_1 = \Delta F_1/\Delta A_1 = I_0\Delta\omega/\Delta A_1 = (I_0/\Delta A_1)\,(\Delta A_1 \cos\theta)/D^2 = (I_0/D^2)\cos\theta \quad (6)$$

The illuminance of receiver ΔA_2 is

$$E_2 = (I_2/D^2)\cos\theta \quad (7A)$$

which, for a source obeying Lambert's law, is

$$E_2 = (I_0/D^2)\cos\alpha\cos\theta \quad (7B)$$

In the case of normal incidence the illuminance of the two receivers

$$E_1 = I_0/D^2;\ E_2 = I_2/D^2 \quad (8)$$

Equation 8 expresses the well known inverse square law of illumination. Equation 6 or 7 expresses the combination of two fundamental laws of illumination; the inverse square law and the cosine law. The inverse square law, which is the basis of most photometers, applies to large extended sources if D is considerably larger than the extension of the source. Thus, Eq. 8 holds to within about one percent if D is at least five times the greatest linear dimension (the diagonal of the raster on a cathode-ray tube screen) of the source. Equation 8, rewritten in the form

$$I_0 = E_1D^2;\ I_2 = E_2D^2 \quad (9)$$

serves as a basis of determining the intensity of candlepower of extended sources if D is again at least five times the greatest linear extension of the source.

The luminance B of the surface A_0 (Fig. 2) in any direction α is the ratio of the intensity I_2 in that direction to the area of the projection of A_0 on a plane perpendicular to this direction so that

$$B = I_2/A_0\cos\alpha \quad (10)$$

Luminance is measured in candles per square meter in mks units. If Lambert's law is obeyed, then

$$B = \frac{I_0\cos\alpha}{A_0\cos\alpha} = \frac{I_0}{A_0} = B_0 \quad (11)$$

and the luminance of a surface is independent of α. The brightness sensation depends upon the luminance of the surface. Hence, if the surface obeys Lambert's law, its luminance is the same in all directions, and it will appear equally bright from all angles.

The luminous emittance L of a surface is the total luminous flux the surface emits per unit of area

$$L = F/A \quad (12)$$

Luminous emittance is measured in lumens per square meter in mks units. The luminous emittance of a surface obeying Lambert's law is

$$L = \pi B \quad (13)$$

Thus a perfectly diffusing surface with a luminance of B candles per square meter emits πB lumens per square meter. If the area of the surface is A square meters, then it emits πBA lumens.

Equation 13 is the basis for another unit of luminance called meter-lambert. One meter-lambert (equal to $1/\pi$ candle per square meter) is the luminance of a perfectly diffusing surface emitting, reflecting or transmitting one lumen per square meter. This lambert unit is extremely convenient when dealing with reflecting and transmitting surfaces which are perfectly diffusing. For, if these surfaces do not absorb any light, then the number of lumens incident on them is equal to the number of lumens transmitted or reflected, and the illuminance in lumens per square meter equals the luminance in meter-lamberts.

Besides the mks units given above, there are many others in widespread use. They differ from the mks units only in the fact that different units of area are used. Tables IV and V give the names and the relative magnitudes of the more commonly used units of illuminance and luminance.

Table III—Conversion Factors for Units of Luminous Intensity

UNIT	Int'n'l Candle	New Candle	Hefner Candle
One Int'n'l Candle	1	1.02	1.11
One New Candle	0.98	1	1.09
One Hefner Candle	0.90	0.92	1

Table IV—Conversion Factors for Units of Illuminance

Unit	Lumen/M² or Meter-Candle or Lux	Lumen/Ft² or Foot-Candle	Lumen/Cm² or Phot	Millilumen/Cm² or Milliphot
One Lumen/M² or Meter-Candle or Lux	1	0.0929	0.0001	0.1
One Lumen/Ft² or Foot-Candle	10.76	1	0.001076	1.076
One Lumen/Cm² or Phot	10,000	929	1	1,000
One Millilumen/Cm² or Milliphot	10	0.929	0.001	1

Photometric Measurements

The methods of light measurement may be divided into two classes: visual photometry, and physical photometry.

In visual photometry the human eye is used as the detector. Although the human eye is incapable of measuring, it is capable of fairly accurately judging the equality of luminances of adjacent areas. In a visual photometer, two adjacent areas of a screen are illuminated by a calibrated source and an unknown source. The observer adjusts the illuminance on the half-field produced by the calibrated source, (by varying the distance between source and screen) until he judges the two half-fields to be equally bright. The better visual photometers (such as the Macbeth Illuminometer) use a Lummer Brodhun cube to split the field. Relatively accurate measurements may be made with visual photometers only if the chromaticities of the calibrated and unknown sources are approximately the same. Although a series of fil-

Table V—Conversion Factors for Units of Luminance

UNITS	Candle per sq Cm	Candle per sq In.	Candle per sq Ft	Candle per sq M	Cm-Lambert	Foot-Lambert	Milli-Lambert	Meter-Lambert
One Candle/Cm² or Stilb	1	6.452	929	10,000	3.142	2,919	3,142	31,420
One Candle/In²	0.1550	1	144	1,550	0.4869	452.4	486.9	4,869
One Candle/Ft²	0.00108	0.00694	1	10.764	0.00338	3.142	3.38	33.82
One Candle/Meter	0.0001	0.000645	0.0929	1	0.0003142	0.2919	.3142	3.142
One Cm-Lambert	0.3183	2.054	295.7	3,183	1	929	1,000	10,000
One Foot-Lambert	0.000343	0.00221	0.3183	3.426	0.0010764	1	1.0764	10.764
One Millilambert	0.000318	.002054	0.2957	3.183	0.001	0.929	1	10
One Meter Lambert	0.0000318	0.0002054	0.02957	0.3183	0.0001	0.0929	0.1	1
	Intensity (measured along line of sight) per unit of area (measured in plane normal to line of sight)							

ters may be used to relieve this limitation, measurements upon sources of different colors (heterochromatic photometry) are generally subject to considerable errors unless a flicker photometer is used.

In physical photometry, the detector is generally a photovoltaic or photoemissive cell. A cell corrected with a suitable filter, so that its sensitivity throughout the spectrum is proportional to the standard luminosity curve will give standard photometric values regardless of the color of the light. The most important error in physical photometry is generally due to the difference between the spectral response of the cell and the standard luminosity curve. Other errors arise from the directional, temperature and fatigue characteristics of cells. Most commercial light measurements are now made using a photovoltaic cell with a correcting filter to give a response typical of the human eye.

Although physical photometry is obviously the ideal, visual photometry will continue to be used because no portable physical photometer has as yet been developed which is as universal a light measuring instrument as the Macbeth Illuminometer. It can be used to measure the light from small or large areas and, with suitable filters, covers a very wide range of intensities. For trained observers, the Macbeth will yield reasonably accurate and consistent results over a wide spectral range. The correct manner of using the Macbeth illuminometer is given in the instruction book issued by the manufacturer (Leeds and Northrup).

However, because of the spectral distribution of the light emitted by cathode-ray tubes and in the case of semiroutine measurements especially by nonspecialists, it is preferable to use a physical photometer. A barrier-layer cell photometer, such as a Weston Photronic cell with a Viscor filter, will, under the circumstances, often yield more consistent and more standard results than those obtained with a Macbeth if as much care is taken in its calibration and reasonable care is exercised in following procedure (such as that outlined by L. E. Barbrow, A Photometric Procedure Using Barrier-Layer Photocells, Jour. of Res. Nat. Bureau of Standards. 25, 703, 1940). However, the barrier-layer cell photometer is not very suitable for the measurement of very low intensities, or of the ratio of luminance of small areas, as is required in measuring contrast gamma and hum. Under these circumstances it may be necessary to use the Macbeth and, whenever possible, calibrated filters to match the color of the light from the luminescent screen should be used.

The measurement of contrast, gamma and hum involves primarily the measurement of light intensity ratios. The absolute value of luminance need not be known and the spectral characteristic of the light stays approximately constant throughout the measurement. It is believed that a physical photometer, such as a well stabilized vacuum photocell arrangement preferably with an optical system, and several field limiting apertures should be developed for the purpose.

The following procedure may be used for measuring with a barrier-layer cell the luminance (brightness) of a uniformly emitting area of a cathode-ray tube screen: (1) Place a good mask with an opening of accurately known area A over the tube face. (2) Locate the cell facing the tube and one foot away.

The luminance in foot-lamberts is then $\pi E/A$ where E is the reading of the meter in foot-candles. If the area (in square feet) of the aperture in the mask is standardized, then the factor π/A can be included in the calibration of the meter and thus the luminance in foot-lamberts may be read directly. The largest linear dimension of the aperture in the mask should be kept below six inches, if the error, due to the assumption that the inverse square law holds for extended surfaces, is to be less than about 0.06.

The same procedure may be adopted in the case of projection receivers, except that here the luminance should be measured at least in two directions: normal and where the luminance has dropped to a preassigned value.

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Design Curves for Parallel-T Network

Chart presents generalized design curves from which transmissions at various deviations from resonant frequency can be read directly. Design equations are also presented, and conclusions as to properties of parallel-T networks under usual conditions are drawn

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PARALLEL-T NETWORKS are coming into common use because of their simplicity, economy and effectiveness. To simplify their design, generalized transmission curves for conditions ordinarily encountered are presented.

Characteristics of Network

Resonance equations for the general parallel-T network are given in Table I, which contains other pertinent equations and the circuits which they describe. The analysis need not be restricted to symmetrical networks in which $R_1 = R_2$ and $X_1 = X_2$ or even to the condition that $R_1 = X_1$ at resonance. For the general case the parameters m and k can be defined at resonance by the two relations of Eq. 2, and with the aid of Eq. 1 the relations of Eq. 3, 4, 5 can be derived.

The general expression for transmission through a parallel-T network is given by Eq. 6 where f is the operating frequency and f_0 is the resonant frequency of the network; the other terms are defined by the relations of Eq. 7. Usually the parallel-T network is made using capacitors for the reactive arms. The resonant frequency of such a network is given by Eq. 8; R_3 does not appear in this relation because it is uniquely determined by the other parameters. The arms of the capacitive network can be designed from the relations of Eq. 9.

Considerable information about the network can be obtained from an examination of part of Eq. 6

$$\frac{\alpha + \beta\gamma^2}{\alpha\beta\gamma} = \frac{1 + m + 2k}{k} \qquad (10)$$

which, for $m = 1$, reduces to $2(1 + k)/k$ and for $k = 1$ reduces further to $3 + m$.

These relations show that the larger the magnitude of Eq. 10, the less the selectivity of the network. Increasing m for a fixed value of k increases the value of Eq. 10, decreasing the selectivity, while increasing k causes Eq. 10 to decrease, approaching 2 as a limit, and consequently increasing the selectivity. The effect can be seen in the design chart in which Eq. 6 is plotted for various values of k and m; only the low side of resonance is shown because the curves are symmetrical.

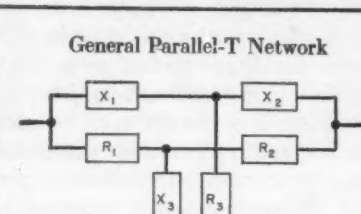
An approximate transmission formula when $k = m = 1$ for the frequency range from $f = 0.9f_0$ to $f = 1.1f_0$ is

$$T = j\,[(f/f_0) - 1]/2 \qquad (11)$$

This equation also illustrates the fact that there are approximately 90 degrees of phase shift near resonance, lagging at frequencies below, leading at frequencies above.

Table I—Design Equations for Parallel-T Network

General Parallel-T Network



General Resonance equations

$$X_1X_2 = (R_1 + R_2)R_3 \qquad (1A)$$

$$R_1R_2 = (X_1 + X_2)X_3 \qquad (1B)$$

Relationships between parameters

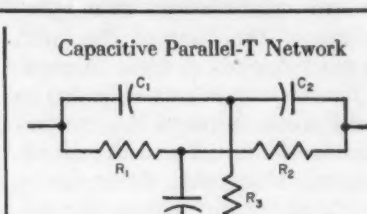
$$X_1 = mR_1;\ R_2 = kR_1 \qquad (2)$$

$$X_2 = kR_1 = kX_1/m \qquad (3)$$

$$R_3 = [mk/(1 + k)]R_1 \qquad (4)$$

$$X_3 = [k/(m + k)]R_1 \qquad (5)$$

Capacitive Parallel-T Network



Resonance frequency of network

$$f_0 = \frac{1}{2\pi[R_1R_2\{C_1C_2/(C_1 + C_2)\}C_3]^{1/2}} \qquad (8)$$

Design of capacitive network, all components related to R_1 or C_1

$$C_1 = 1/2\pi f_0 mR_1 \qquad (9A)$$

$$C_2 = mC_1/k;\ R_2 = kR_1 \qquad (9B)$$

$$C_3 = (m + k)/2\pi f_0 kR_1 = m(m + k)C_1/k \qquad (9C)$$

$$R_3 = mkR_1/(1 + k) \qquad (9D)$$

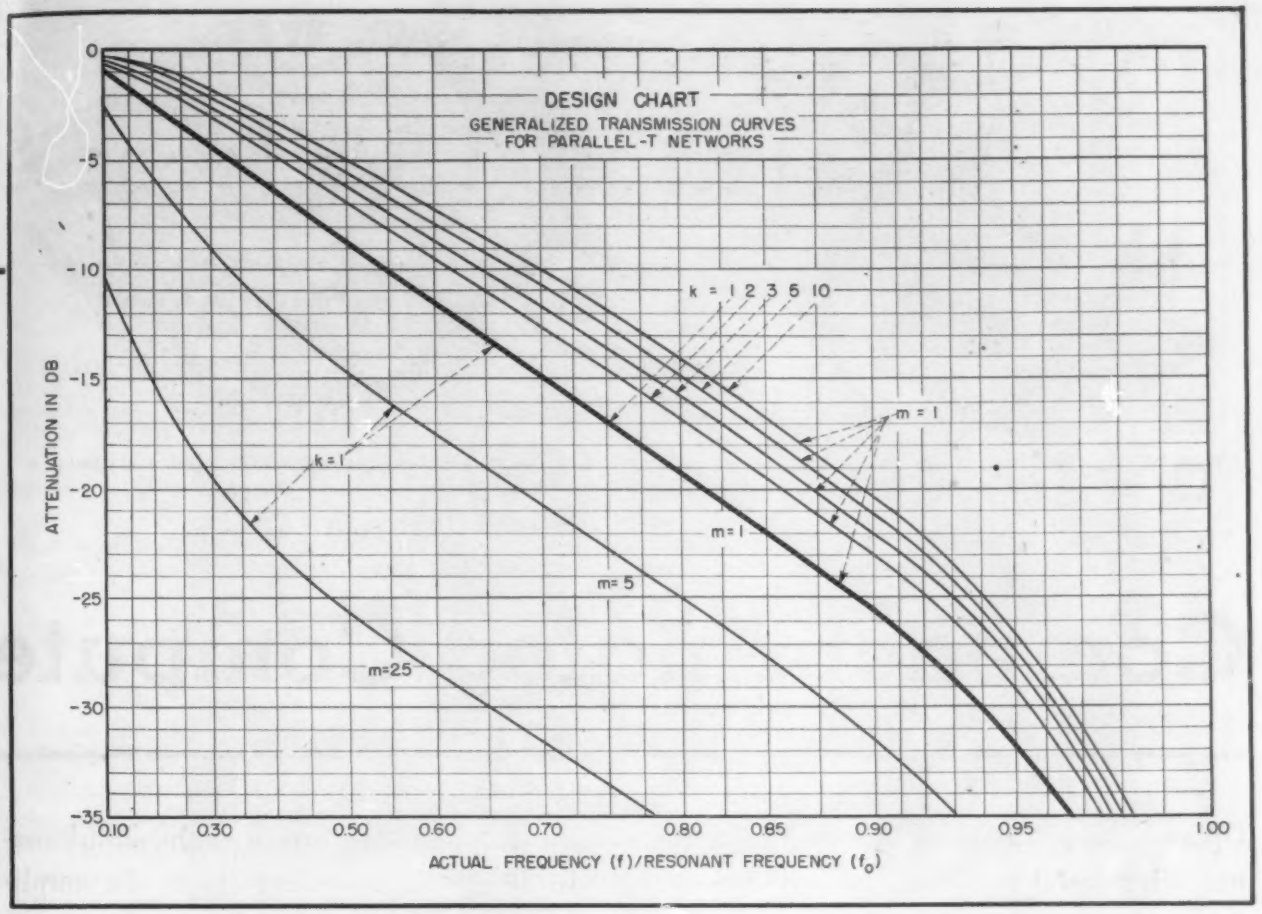
General expression for transmission through a parallel-T network

$$T = \frac{1}{1 + j\,\dfrac{(f/f_0)}{1 - (f/f_0)^2}\,\dfrac{\alpha + \beta\gamma^2}{\alpha\beta\gamma}} \qquad (6)$$

$$\alpha = \frac{R_2}{R_1 + R_2} = \frac{k}{1 + k} \qquad (7A)$$

$$\beta = \frac{X_2}{X_1 + X_2} = \frac{k}{m + k} \qquad (7B)$$

$$\gamma = \frac{X_1 + X_2}{R_1 + R_2} = \frac{m + k}{1 + k} \qquad (7C)$$



The parallel-T network loads the driving circuit at all frequencies, and at resonance presents an input impedance of $R_1/2$ for any value of k when $m = 1$. Below resonance this impedance increases and above resonance it decreases. Loading the output of the network with an external load reduces the transmission on both sides of resonance, although the effect is greater on the low-frequency side. However, loading with a value as low as $3(1 + k)R_1$ reduces the transmission less than a decibel in the region from $f = 0.5f_0$ to $f = 2f_0$.

Varying R_3 and either R_1 or R_2 allows sufficient adjustment to tune the network to resonance. Each component contributes approximately 0.5-percent change in f_0 for each 1-percent variation from the specified value. An adjustable element should have a range of ±4 times the individual element tolerance to assure the ability of resonating the network.

Table II—Comparison of Computed and Measured Transmissions

Frequency in cycles per second	Transmission in Decibels				
	k = 1 and m = 1			k = 1 and m = 5	
	Computed	Measured	Measured*	Computed	Measured
1,000	——	−65	(1,000 −65.7)	——	——
950	−31.6	−32	(1,053 −32.7)	−37.6	——
900	−25.6	−26.5	(1,110 −26.4)	−31.6	−33
850	−22.0	−22.1	(1,170 −22.3)	−27.5	——
800	−19.1	−19.4	(1,250 −19.2)	−25.0	−26.5
700	−14.9	−15.3	(1,430 −15.2)	−20.8	−22.0
600	−11.9	−12.0	(1,670 −11.8)	−17.5	−19.0
500	− 9.15	− 9.5	(2,000 − 9.4)	−14.8	−16.0
300	− 4.35	− 5.0	(3,300 − 4.8)	− 9.0	−10.0
100	− 0.7	− 1.9	(10,000 − 0.9)	− 2.5	− 3.0

* These two columns give the symmetrical frequency on the high side of resonance as compared to the frequency of the extreme left-hand column and the corresponding transmission. The transmissions indicate the degree of symmetry of the response.

A parallel-T network resonant at 1,000 cps and with $k = m = 1$ was built from the foregoing equations. From Eq. 9 $R_1 = R_2 = 16{,}000$ ohms, $R_3 = 8{,}000$ ohms, $C_1 = C_2 = 0.01$ μf, and $C_3 = 0.02$ μf. With ±1-percent tolerance capacitors, actual values of the resistances required for resonance were $R_1 = 15{,}800$ ohms, $R_2 = 16{,}000$ ohms, $R_3 = 8{,}000$ ohms. The computed transmissions (from the design chart) and the measured values are presented in Table II. Results for a similar network, but for which $m = 5$, are also given in this table.

The measurements at resonance were remade by filtering out the second and third harmonics with parallel-T networks and rejecting hum frequencies with a high-pass filter. Under these conditions an attenuation of 115 db was measured.

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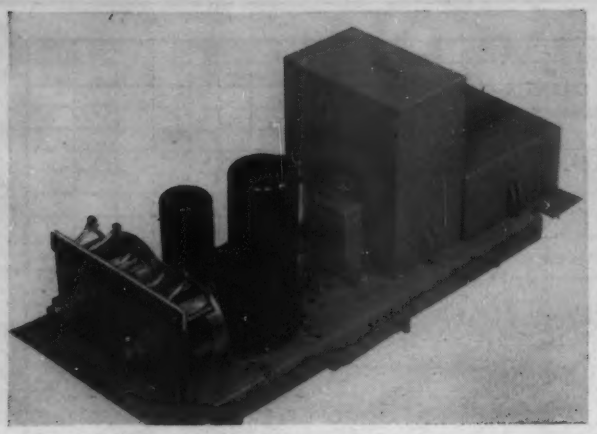
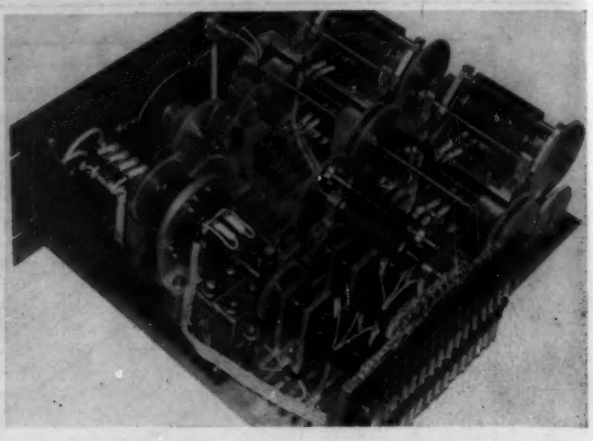


Basic interchangeable amplifiers are used wherever possible



Servomechanism plates are built to high mechanical tolerances

Compact Analog Computer

Operation and facilities of a computer for obtaining dynamic solutions of the simultaneous differential equations usually encountered in design engineering. Here d-c amplifiers add and integrate, while servos multiply or divide variables and resolve or add vectors

By SEYMOUR FROST

Reeves Instrument Corp.
New York, N. Y.

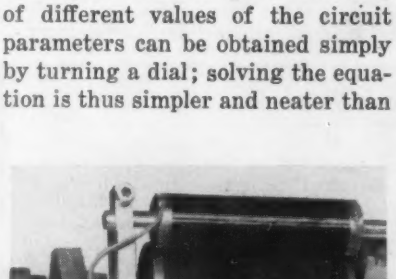
PROBLEMS can usually be stated mathematically but obtaining numerical solutions is often impractical because of the enormous amount of computation that is required. In the field of electronics, for example, the relationship between the current and circuit elements of a tuned plate oscillator is

$$\frac{d^2i}{dt^2} + \frac{di}{dt}\left[\frac{r_P rC + L - \mu M}{r_P LC}\right] + i\frac{r_P + r}{r_P LC} = 0$$

Most of us find it easier to build such an oscillator and use cut and try methods in selecting its components than to solve this second order linear differential equation.

If the equipment is goal, this approach is satisfactory, but when a fundamental design principle is being studied the exact solution is required.

The REAC (Reeves Electronic Analog Computer) can solve such problems, and more complex ones, in a relatively short time. Once the problem has been set into the REAC, the effects upon oscillation of different values of the circuit parameters can be obtained simply by turning a dial; solving the equation is thus simpler and neater than changing components on a breadboard.

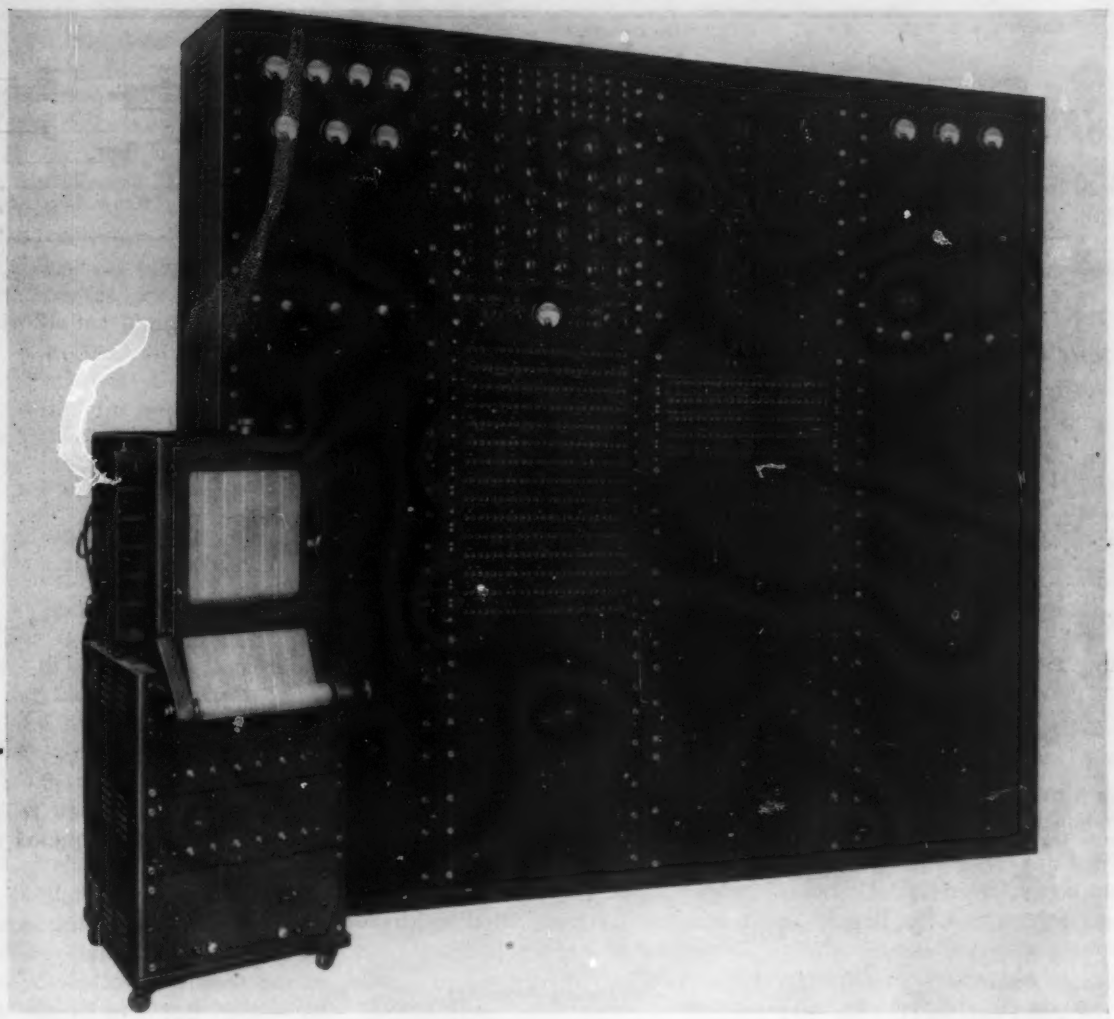


Interchangeable cylinders carrying spiral contacts provide the special functions

Computer "Turns the Crank"

What is actually done when an equation is set into the REAC is to simulate the system to which the equation applies. For example, using aerodynamic relationships expressed in terms of ordinary, initial valued, linear and nonlinear simultaneous differential equations, the REAC can be set so that it simulates the flight of an aircraft. The effect of contemplated design changes or the design that will give optimum performance can be determined without actually building an aircraft or model. Control equipment can be tested by using the REAC to simulate an aircraft. Similarly, chemical and other industrial processes can be simulated and controlled.

The REAC was developed for the Special Devices Center of the Office of Naval Research as a gen-



Elements of computer are interconnected by plugging into jacks at a common patch bay; recorder plots solution

eral-purpose analog computer. Using it on problems submitted by various airplane manufacturers and universities, it was found that the REAC cut the cost of computation 95 percent and produced answers as adequate as those resulting from hand computation by experts. Extensive use of the machine on problems shows that it reduces the man-days required to obtain solutions to about a thirtieth of that required by hand methods using desk computers.

The standard REAC consists of the Computer Unit, the Servomechanisms Unit, a Recorder Unit, and associated power supplies. Because the power supplies do not contain computing controls they need not be located with the other units in which all the computing elements are mounted.

The computing elements generate and operate on direct voltages that are proportional to the terms in the mathematical problems set into them. There are seven summing amplifiers, seven integrating amplifiers, four limiters, six initial condition potentiometers, twenty scale factor potentiometers, and automatic balancing and overload relay units. The principal elements are shown diagrammatically in Fig. 1.

Summing Amplifiers

The function of a summing amplifier is to furnish an output voltage whose value is the negative of the algebraic sum of several input voltages. Connection to the seven inputs of each amplifier is by means of telephone jacks on the patch bay in the front panel. One of the inputs has an amplification of ten, two have amplifications of four, and the rest have amplifications of one. Two volts applied at the amplification-ten input, for example, would produce an output of −20 volts.

This operation is accomplished as follows: Figure 1A is a block diagram of the summing amplifier with two inputs, where R is the value of the feedback resistor of a high gain d-c amplifier and R/A and R/B are the values of the input resistors. Assuming no grid current, the following five equations can be written where $-\mu$ is the gain of the amplifier without feedback, e_1 is the first input voltage, e_2 the second, e_g is the grid voltage into the amplifier proper, e_o is the output voltage from the amplifier, I is the current through R, I_1 is the current through R/A, and I_2 is the current through R/B, consequently

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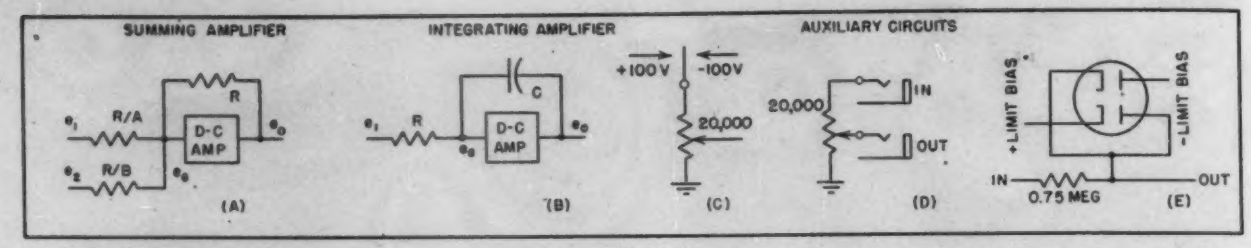

FIG. 1—Computer includes (A) summing and (B) integrating amplifiers, (C) initial condition and (D) multiplying pots, and (E) limiters

$$I = I_1 + I_2 \quad (1)$$

$$e_1 - I_1R/A = e_g \quad (2)$$

$$e_2 - I_2R/B = e_g \quad (3)$$

$$e_o = -\mu e_g \quad (4)$$

$$e_g - e_o = IR \quad (5)$$

From Eq. 1 and 5 comes the following

$$-e_o = IR - e_g = RI_1 + RI_2 - e_g \quad (6)$$

and from Eq. 2 and 3

$$I_1 = (e_1 - e_g)A/R \quad (7)$$

$$I_2 = (e_2 - e_g)B/R \quad (8)$$

therefore from Eq. 6, 7, and 8

$$e_o = e_1A + e_2B - e_oA - e_gB - e_g \quad (9)$$

From Eq. 4, $e_g = -e_o/\mu$, so Eq. 9 is

$$-e_o = e_1A + e_2B - e_o(1 + A + B)/\mu \quad (10)$$

The gain of the amplifier is about 75,000, hence

$$e_o(1 + A + B)/\mu \simeq 0 \quad (11)$$

and can be neglected with little resulting error, so that Eq. 10 may be written

$$e_o = -(e_1A + e_2B) \quad (12)$$

Equation 12 states that the output voltage equals the negative sum of the input voltages each multiplied by a multiplication factor determined by the ratio of the feedback resistor to the input resistor.

The schematic of the summing amplifier is shown in Fig. 2. It is a three-stage d-c amplifier with a one-megohm feedback resistor from the plate of the final stage to the control grid of the input stage. The variable resistor in the cathode of the input stage is provided to stabilize the gain of that stage. The stage gain is stable when the fixed cathode resistor equals $1/g_m$ of the 6SL7. To achieve this condition, the bias of the tube is varied by means of the Compensate resistor. The compensated condition corresponds to the condition of maximum gain in the amplifier, which fact is used to indicate the correct setting.

The bias of the second stage is also adjustable (the grid resistor leads to a bias source in the automatic balancing system; see below) by means of the Balance potentiometer. This spot is used to adjust the gain so that, with the input to the first stage open-circuited (by the zeroing relay), the output of the amplifier is zero. Because maintaining the balance condition is important for accurate results an automatic balancing system is provided that balances all the amplifiers sequentially in about a minute.

The accuracy of the amplifier's operation is limited by the tolerances of the components. The input and feedback resistors, which determine the multiplication factors, have a tolerance of 0.1 percent and all other resistors, with the exception of those in the filtering networks which are not critical, are temperature compensated and have tolerances of 1 percent.

Integrating Amplifier

The integrating amplifier provides an output voltage equal to minus the time integral of the algebraic sum of several input voltages, each of which is multiplied by a fixed factor as in the summing amplifier. This is achieved by the arrangement shown in the block diagram in Fig. 1B. The following relations in the circuit can be written, again assuming no grid current and using the symbols as before

$$e_o = -\mu e_g \quad (13)$$

$$e_i - e_g = IR \quad (14)$$

$$e_g - e_o = (1/C)\int_o^t e_i dt + e_{ic} \quad (15)$$

where $e_{ic} = -e_o$ at $t = 0$, or the initial voltage from which the integration takes place. Eliminating I between Eq. 14 and 15 gives

$$e_g = e_o + (1/RC)\int_o^t e_i dt - (1/RC)\int_o^t e_o dt + e_{ic} \quad (16)$$

Combining Eq. 16 and 13 gives

$$e_o + (e_o/\mu) + (1/\mu RC)\int_o^t e_o dt = -(1/RC)\int_o^t e_i dt - e_{ic} \quad (17)$$

Because μ is very large, Eq. 17 can be written

$$e_o = -(1/RC)\int_o^t e_i dt - e_{ic} \quad (18)$$

If two input voltages are applied, the output voltage is

$$e_o = -(1/R_1C)\int_o^t e_1 dt - (1/R_2C)\int_o^t e_2 dt - e_{ic} \quad (19)$$

where R_1 is the input resistance through which e_1 is applied and R_2 is that for e_2.

The integrating amplifier is the same as the summing amplifier (Fig. 2) except for the replacement of the feedback resistor by a feedback capacitor and by the use of two dpdt relays in the input circuit instead of one spdt relay for the summing amplifier. When one of the two relays for the integrator is energized, the inputs to the amplifier are disconnected so that connections can be made while setting up a problem. When the other relay is energized, the integrating amplifier is connected as a summing amplifier with a multiplication of one. The input to the amplifier in this condition is only the initial condition voltage taken from a panel-mounted initial condition potentiometer (Fig. 1C) and applied at the amplifier's initial condition input. This input determines the voltage across the capacitor from which the integration starts. When both relays are energized, the feedback capacitor and resistor are shorted out and the input to the amplifier is open-circuited, the conditions necessary for balancing the amplifier.

There are seven integrating in-

puts and one initial condition input for each integrating amplifier. Because the multiplying factor for each integrator input equals $1/RC$ (Eq. 19), by using different input resistors with a fixed one-microfarad capacitor, different multiplying factors are obtained. For example, the input with a multiplication factor of ten consists of a 0.1-meg resistor; with the 1-μf feedback capacitor. This give $1/RC = 1/(10^5 \times 10^{-6}) = 10$. The multiplying factors of the integrating amplifier are the same as those of the summing amplifier; connections are also made by jacks on the patch bay.

Auxiliary Circuits

As shown by the above discussion, the summing and integrating amplifiers develop outputs that are opposite in sign to their inputs, and offer only fixed multiplications of 10, 4, and 1. These limitations are overcome by the inverting amplifiers, each of which is simply a summing amplifier with a multiplication factor of unity to provide a means of changing sign when necessary and scale factor pots.

The scale factor potentiometers (Fig. 1D) make intermediate multiplication factors available. Each of the 24 scale factor potentiometers is a linear ten-turn 20,000-ohm Micropot controlled by a dial on the front panel of the computer unit. For each scale factor pot there is mounted on the patch bay an input jack that is connected to one end of the pot and an output jack connected to the tap; the other end of the pot is grounded. If it is desired that a signal input to an amplifier be multiplied by three, the signal is connected to the input jack of a scale factor potentiometer that is set to 0.75 and then applied to a multiplication by four jack of a summing amplifier. (The same result could be obtained more directly by another design for the computer, but this method provides considerable flexibility, which is essential to a general-purpose machine.) The whole range of the scale factor potentiometer is covered by ten turns of the panel dial, which has 100 divisions. This gives three-place accuracy in the setting of the potentiometer, but the linearity of the pot has a tolerance of 1%.

In many problems certain variables cannot exceed certain known limits. Four limiters (Fig. 1E) are provided to keep the signal voltages corresponding to these variables between the known upper and lower limits; for example, the limits of motion of a shaft between two stops. Each limiter consists of a pair of biased diodes back to back that clamp the signal at the preset limit if it tries to exceed it. The resistor (0.75 meg) in series with the output affects the multiplication factor of any summing amplifier input to which the limiter is connected by increasing its effective input resistance. For example, if a voltage is connected through a limiter to the multiplication by four input of an amplifier, the total input resistance will become one megohm, giving unity feedback to input resistance ratio.

In addition to the computing elements, there are also an automatic balancing unit (mentioned previously) and an overload relay in the computing unit. The automatic balancing unit is provided so that the operator can balance a selected amplifier or all of them in sequence by simply setting a switch on the front panel. When the switch is set to the number indicating a particular amplifier, the input to that amplifier is opened and the output connected to a servo that adjusts the bias of the second stage of the amplifier until its output is zero. When that amplifier is balanced, if the switch is set in the automatic position, the balancing unit steps itself to the next amplifier in the balancing sequence, balances it, and continues until the sequence has been completed.

The overload relay unit is incorporated to indicate to the operator when and what amplifier is operating outside the limits at which it will produce accurate results (between plus and minus 100 volts). The output of each amplifier is connected to a relay in the overload unit that is energized whenever the output of that amplifier exceeds the 100-volt limit. If a relay is tripped it ignites a red light on the panel indicating which amplifier has been overloaded and sounds a warning gong.

Using the Computor

The computer unit alone can solve ordinary initial-valued linear differential equations up to the seventh order. The equation for an oscillator presented at the introduction of this article is typical. Figure 3 shows the basic oscillator circuit to which this equation applies and the computer set up to solve it for the case that

$$(r_P rC + L - \mu M)/r_P LC = 16$$
$$(r_P + r)/r_P LC = 6.25$$

and the current i is represented by the variable y with the initial conditions at zero time of $y = 0.5$ and $dy/dt = 0$.

To set up the computer the elements are connected as shown by means of patch cords joining the proper inputs and outputs through the patch bay. All amplifier inputs are disconnected by means of the relays on the amplifiers while the problem is being set up and the initial conditions prepared. When the circuit has been completed, the first initial condition set at 0 volt and the second at 5 volts, a switch is thrown setting the relays in the operating positions. The solution then takes place and is recorded by picking off voltages at the outputs

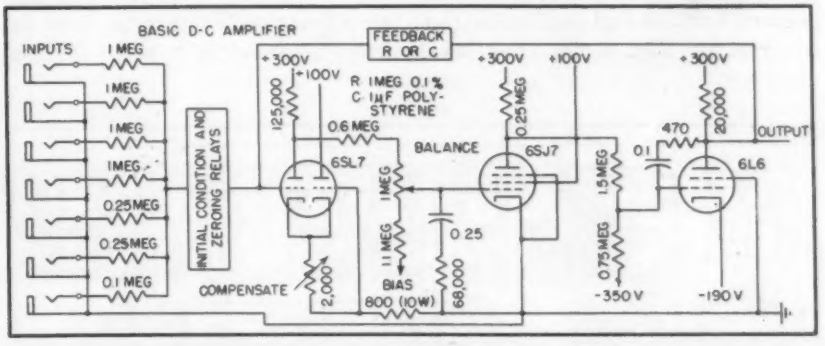

FIG. 2—Basic high-gain directly coupled amplifier used in computer

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of the appropriate amplifiers. When the solution is no longer of interest, the switch is thrown back, opening the inputs and resetting the initial conditions. To obtain families of solutions the potentiometer settings are changed to the next set of conditions and the next solution obtained without disturbing the connections. In this way a large group of solutions can be determined in a very short time.

Servomechanisms Unit

The function of the servomechanisms unit is to multiply and divide two or more variables, multiply by trigonometric and special functions, and resolve and add vectors. This unit contains two multiplying servos and two resolving servos.

The multiplying servo block diagram is shown in Fig. 4A. The d-c signal servomechanism amplifier contains a vibrator in its input that converts the d-c signal to a-c. The rest of the amplifier consists of three stages of push-pull amplification. The a-c output drives the 10-watt Diehl induction motor whose shaft is coupled to the input of the follow-up potentiometer, which is a linear Helipot whose output is coupled back to the input of the servo amplifier. As long as there is any difference between the signal voltage and the follow-up voltage, a driving a-c voltage will be delivered to the servo motor with such phase as to drive it to the position at which the follow-up voltage equals the signal voltage. In this way the setting of the follow-up pot and the servo motor is determined by the d-c signal input. The tachometer that is also coupled to the servo motor produces a d-c voltage that is fed back to a network in the servo amplifier so as to damp the response of the servo system to prevent hunting and oscillation (on the rest of Fig. 4 this has been omitted for simplicity). Also coupled to the servo motor is the multiplying pot. This basic arrangement is employed for multiplication and division.

Multiplication is obtained with the servo when it is patched to the computer unit as indicated in Fig. 4B. The output voltage z of the multiplying pot is proportional to its angular rotation and to the variable voltage applied across it (y voltage). The action of the servo and follow-up pot is such that the voltage is proportional to the angular rotation determined by the x voltage and the fixed 100 voltage applied across it, therefore $z = xy/100$. A typical multiplying servo has one follow-up potentiometer, four multiplying pots, and accommodations for one functional pot.

The functional potentiometer is used to produce a special complex relationship between a dependent and an independent variable that cannot be produced otherwise. These relations are frequently empirically derived functions that are too complex to be stated analytically. The functional pot consists of a stationary linear card and a rotatable cylindrical form on which is glued a wire that makes contact with the linear card. A voltage is connected across the linear card and the cylinder is rotated by the servo motor so that its rotation is a function of the input to the servo amplifier. The curve that the wire makes around its cylinder is calculated to reproduce the desired function.

Division is accomplished with the multiplying servo and two inverting or summing amplifiers in the computer unit, which are patched to the servo as indicated in Fig. 4C. The input consists of K_1x and K_2y where K_2y does not approach zero too closely (that is, does not decrease below the noise level of the amplifier). The tap voltages are controlled as for multiplication, but the electrical connection is such that the output of the multiplication pot is

$$[(H - h)/2H]\,2K_3(x/y) = (1 - K_2y/100)\,K_3(x/y) = K_3(x/y) - K_3K_2y/100$$

where H is the total displacement from the center to one end of the pot and h is the displacement from center to the actual position of the movable contact. Thus $K_3K_2/100 = K_1$ and hence $K_3 = 100(K_1/K_2)$. From Fig. 4C it can be seen that there are two outputs containing x/y.

Vector Resolution

The resolving servo also provides convenient vector component resolution and vector addition. The block diagram of this unit is shown in Fig. 4D. The type of operation is determined by the position of the switch. With the switch thrown to the left as shown, component resolution is obtained; with it to the right, vector addition is obtained.

For component resolution when three inputs x, y, and θ are fed into the servo, $(y \sin\theta + x \cos\theta)$ and $(y \cos\theta - x \sin\theta)$ appear as outputs. The heart of this manipulation is the magnetic resolver which uses only a-c signals. To convert the d-c input signals to a-c signals whose amplitudes are proportional to the inputs, the x and y signals are fed to potentiometer follow-up servos such as the one used in the multiplying servo. The shaft of the servo motor is coupled to a linear pot across which is 30 alternating volts. The output of the x pot is $z = x(30/100)$ alternating volts.

The outputs of these potentiometers are fed through isolating amplifiers to the two primary (stator) windings of the magnetic resolver. These windings are in space quadrature and each signal produces a quadrature magnetic field proportional to its amplitude. On the rotor of the resolver are wound the two secondary windings, also in space quadrature. The position of the rotor is controlled by the θ signal through another potentiometer follow-up servo. The voltage induced across the one secondary is $E_1 = K_1x \sin\theta + K_2x \cos\theta$ and across

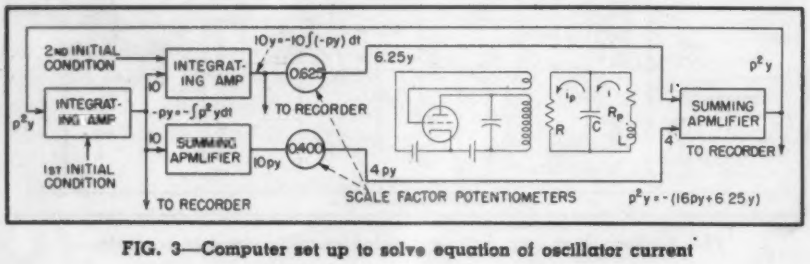

FIG. 3—Computer set up to solve equation of oscillator current

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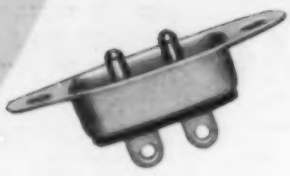

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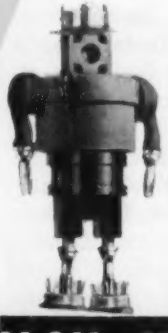

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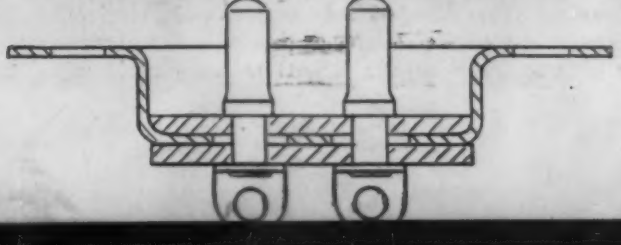

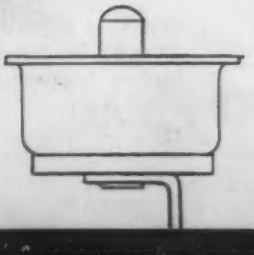

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the other it is $E_2 = K_1 y \cos\theta - K_2 y \sin\theta$.

These are a-c signals, however, and must be demodulated before they can be used in the computer unit. The E_1 output is fed directly through the linear Y-demodulator and a filter network to give one output component. The E_2 output is connected to the linear X-demodulator and its filter through the switch to give the other component output. The system is so designed that K_1 and K_2 both equal unity and the outputs are as desired. If only $y \sin\theta$ and $y \cos\theta$ are desired, the x input is grounded so that x terms drop out.

Vector Summation

In this operation two signals x and y are fed into the servo and $(x^2 + y^2)^{1/2}$ is produced as the output. The θ input is not connected, which leaves it grounded. The x and y signals are fed in as before. However, because the switch which is now to the right, the x component out of the magnetic resolver is connected to the X-demodulator, through an avc amplifier and back to the input of the rotor positioning servo. This feedback drives the magnetic resolver rotor until the output of that winding is zero, and thus $\tan\theta = K_1 y / K_2 x$. Therefore

$$E_1 = \frac{(K_1 y)^2}{[(K_1 y)^2 + (K_2 x)^2]^{1/2}} + \frac{(K_2 x)^2}{[(K_1 y)^2 + (K_2 x)^2]^{1/2}} = [(K_1 y)^2 + (K_2 x)^2]^{1/2}$$

as the output from the remaining secondary of the magnetic resolver. This signal is fed through the Y-demodulator and filter so that the output is $(y^2 + x^2)^{1/2}$. The avc amplifier is provided to make the response of the servo independent of the level of the signals.

The recorder unit consists of a direct-inking six-channel oscillograph with a synchronous motor drive. Each channel has a d-c amplifier whose gain is variable in discrete steps so that the pen deflection is variable from 0.1 volt per division to 10 volts per division. The frequency response of the pen motor is essentially constant from zero to 30 cps. The equivalent of higher frequencies is obtained by extending the time scale. For example, to record a 30-kc signal, a second of recorder time is set equal to a thousandth of a second of real time and $0.001t$ is substituted for t in the equations to be solved. The recorder unit contains its own power supply.

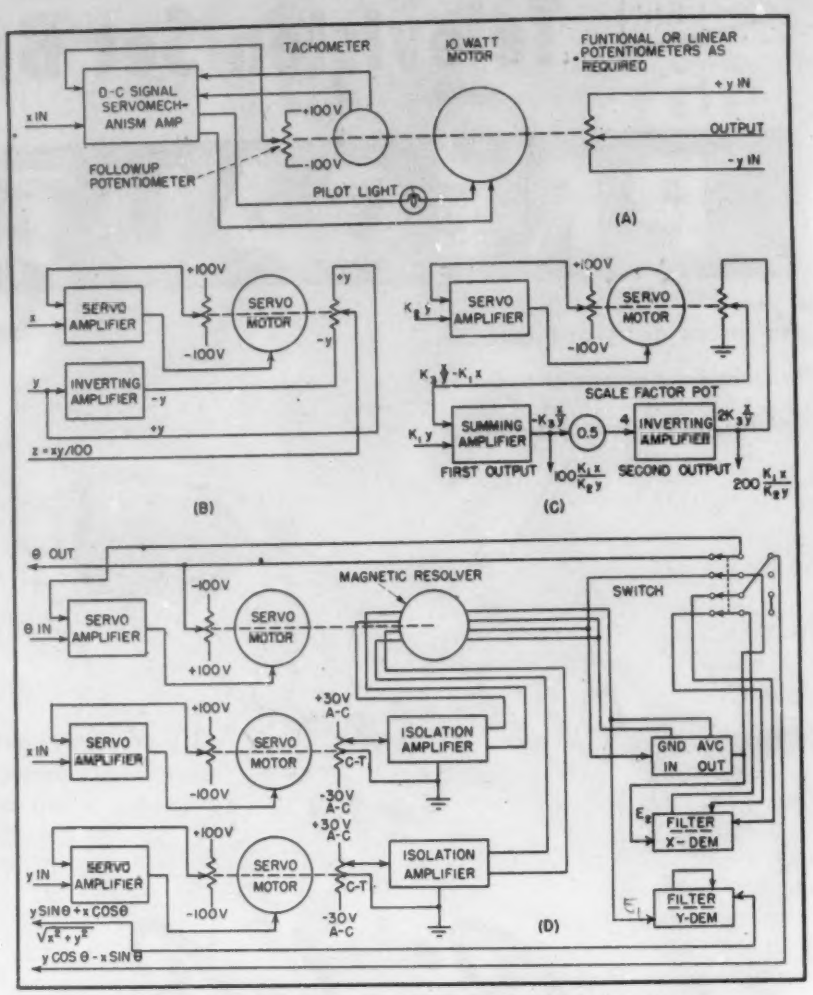

FIG. 4—Servomechanisms manipulate variables and vectors

The separate power supply cabinets for the computer and servomechanism units contain the rectifiers and regulators to produce the closely regulated voltage required. All voltages supplied to the d-c amplifiers in the computer unit are direct including the filament voltages. The power supply cabinets need not be close to the other units; the only controls on them are the power switches.

While the REAC is not the only computer capable of solving differential equations, it is the first successful commercial electronic computer of this type. The accuracy of the REAC is comparable with that of the highest grade of electromechanical systems. Besides, because it employs electronic circuits, it has many advantages over electromechanical analyzers. The REAC is produced at a twentieth of the cost, occupies a twentieth the space, and operates about twenty times faster than a comparable electromechanical computer. All the controls and interconnections are on the front panel of the equipment. There are no gears or parts to change in setting up a problem. Additional units can be connected to extend the capacity of the system. The amplifiers are mounted on separate chasses that are plugged into the computer; they are interchangeable so that if one fails it can be quickly replaced by a spare. Models of the REAC, operated for more than a year, have been out for repair and maintenance less than five percent of the time.

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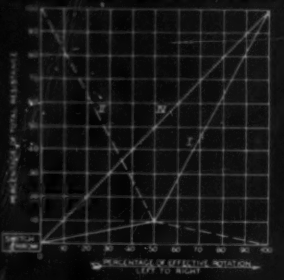
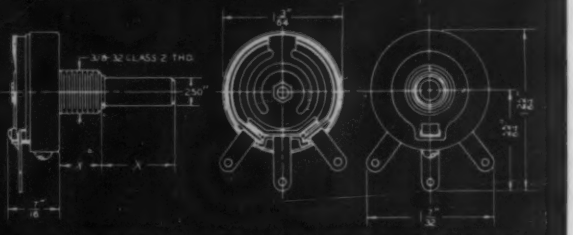
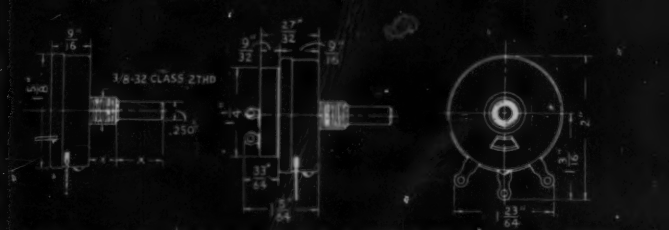
5. Wattage rating (Type M): 4 watts





TYPE C IS A SMALL 2 WATT UNIT, USED AS A METER COMPENSATOR, MINIATURE MOTOR CONTROL AND LIGHT DIMMER.



TYPE M IS USED WHERE POWER DISSIPATION UP TO 4 WATTS IS REQUIRED

TYPE E, RATED AT 7 WATTS, IS WIDELY USED IN PRECISION INSTRUMENTS, RESISTANCE BRIDGES AND OTHER CIRCUITS REQUIRING ACCURATE SETTINGS.

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Generous stocks are normally maintained on these three standard types and production capacity is available at short notice for quantities above "shelf order" level.

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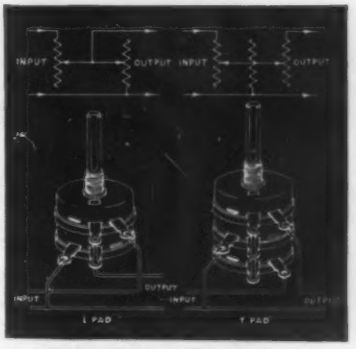
Both "standards" and "specials" are made according to Mallory's high standard of accuracy, and required to pass the rigid inspection checks that continuously maintain the dependability of Mallory Approved Precision Products.



T AND L PAD ATTENUATORS

Designed to provide impedance matching between the input and output of audio circuits or resistive networks to secure maximum power transfer and avoid distortion. They are used in record players, sound motion picture equipment and various other audio distribution systems where multiple speakers are used.

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TUBES AT WORK

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Edited by VIN ZELUFF

Single-Signal Single-Sideband Adaptor 124
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Single-Signal Single-Sideband Adaptor

BY E. W. ROSENTRETER

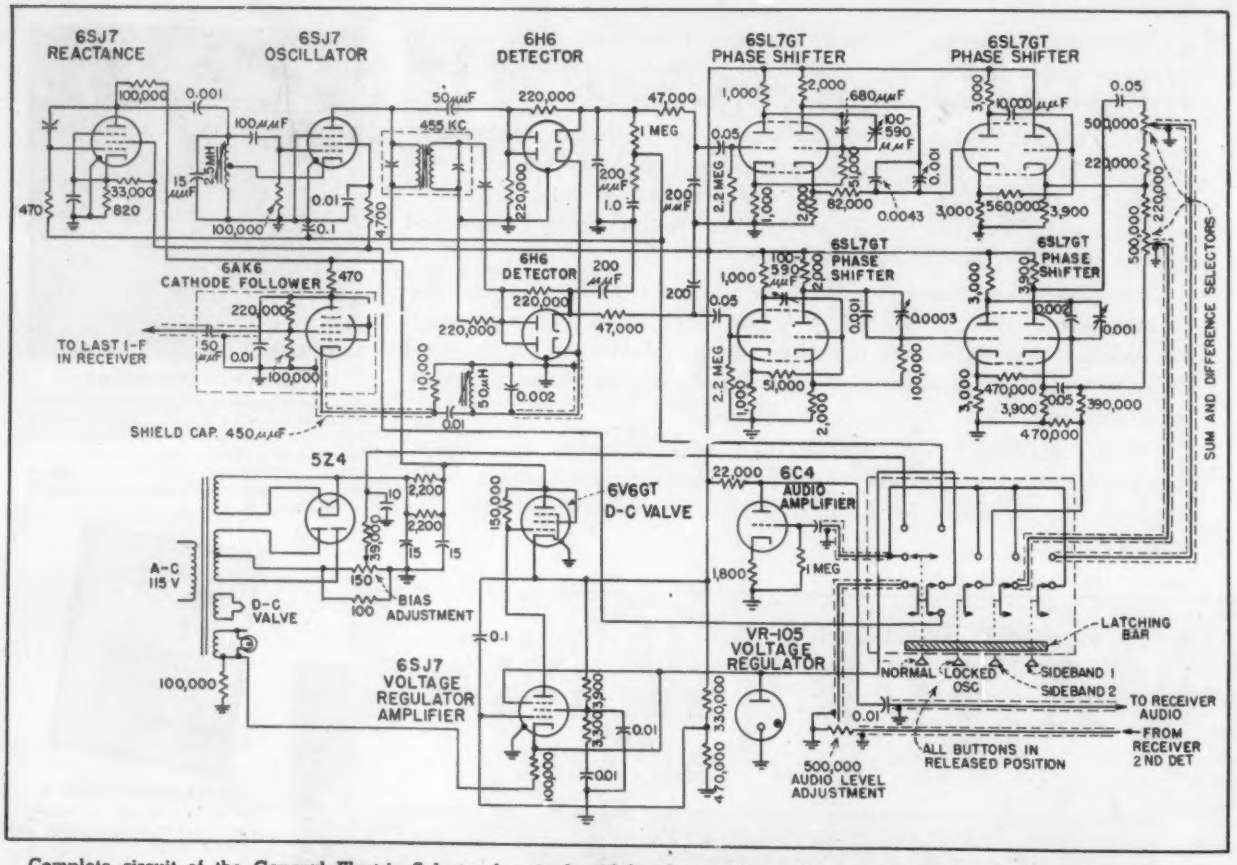
Specialty Division
General Electric Co.
Electronics Park
Syracuse, New York

An ordinary superheterodyne receiver will demodulate a single sideband signal and its accompanying carrier so long as the ratio of carrier amplitude to sideband amplitude is kept sufficiently large, though not without distortion. If, however, the carrier is attenuated below a critical value, complete unintelligibility will result. Commercial single-sideband transmitters now in operation attenuate the carrier 20 db below the sideband level to conserve power and simplify equipment.

If a communications type of receiver is used to demodulate this type of signal some means of carrier reinforcement in the receiver is necessary. This can be done conveniently at the intermediate frequency by using the receiver's beat frequency oscillator to exalt the carrier. Exact tuning is required, as well as excellent stability of transmitter frequency, receiver local oscillator frequency and beat frequency oscillator. If the frequency of any of these varies, an audio beat will be produced.

If the carrier is completely suppressed, then the received single-sideband signal can be satisfactorily demodulated only if the beat frequency oscillator supplies the missing carrier. The critical value between the synthetic carrier and the signal must be maintained or exceeded for acceptable results. Since it is difficult to control accurately the frequencies of the oscillators in both transmitter and receiver, other arrangements usually are resorted to in conventional single-sideband receivers.

Figure 1 shows in block form a simple receiver system using low-frequency filters. With this ar-



Complete circuit of the General Electric Selector for single sideband reception with a conventional communications receiver

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rangement, double conversion is necessary to change the higher radio frequencies used for communications down to the frequency of the filter.

The purpose of the two oscillators is to enable the pass-band filter to accept the desired side-

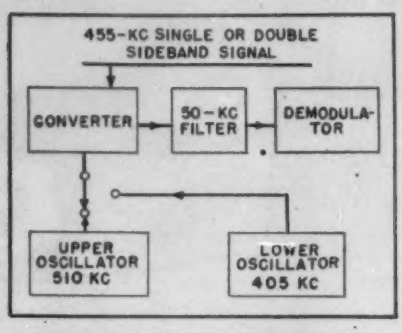


FIG. 1—Filter type of single-sideband receiver

band, whether it be upper or lower. This is done by switching one or the other oscillator into the second converter circuit.

Another single-sideband system, relatively simple in circuit elements, is shown in Fig. 2. This arrangement is used in the General Electric Single Sideband Selector. Reception of a single-sideband signal with or without carrier, and selection of one or the other sideband in a conventional a-m signal, are among the types of transmission which the system handles.

Principle of Operation

Assume that a conventional a-m, double sideband signal is being received. Referring to Fig. 2, the signal from the receiver i-f channel, containing carrier and both sidebands, is fed into two special detectors; 1 and 2. Voltage from an oscillator operating at the same frequency as the i-f channel is also fed into the two detectors. A fixed phase shift of 90 degrees exists between the oscillator voltage applied to detector 1 and detector 2.

The oscillator voltage, or synthetic carrier, is many times greater in magnitude than the incoming signal voltage. Thus the two detectors demodulate the incoming signals at an effective low modulation factor and distortion products are small. Identical audio signals, corresponding to the sideband intelligence are obtained from the two detectors, except for a 90-degree phase difference between them. The amplitude of these signals is directly proportional to the amplitude of the sideband intelligence.

The audio voltages are fed into phase-shift networks A and B, where they undergo an additional 90-degree relative phase shift. The two outputs are fed into a sum and difference circuit, where they are added or substracted algebraically. It can be shown that the sum contains only upper sideband information, for example, and that the difference contains only lower sideband information. (See: Simplified Single-Sideband Reception O. G. Villard, Jr. ELECTRONICS, May 1948.) Selection of one or the other is easily done by a switch, which selects the additive or subtractive process. The same switch also selects an output containing both sidebands.

Lattice Networks

Since the oscillator operates at one frequency only, it is quite simple to create and maintain a 90-degree phase shift of its voltage for application to detector 2. To be of any practical value, the sidebands must be wide enough to carry the desired intelligence. Suppose for instance that an audio voice frequency range of 100 cycles to 4,000 cycles is desired. Then the two sidebands will each be up to 4,000 cycles wide, so that the A and B networks must maintain a 90-degree phase difference over the full 100 to 4,000-cycle audio band. The wideband phase-shift networks were devised by R. B. Dome, and were described in detail in ELECTRONICS, December 1946. Briefly, the manner in which they function is that phase shift increases nearly linearly with the logarithm of the frequency. Thus

$$\text{Phase A} = K + \log f$$
$$\text{Phase B} = K + \log tf$$

Substracting phase B from phase A

$$\phi A - \phi B = K + \log f - K - \log tf$$
$$= \log f - \log f - \log t$$
$$= -\log t$$

where K and t are constants and f is the frequency. Thus the difference in phase shifts between A Network and B Network is a constant, regardless of frequency.

With two networks composed of three RC lattices as shown in Fig. 3 and through proper choice of component values, a frequency coverage ratio of 100 to 1 may be accomplished. Figure 4 shows that although the applied voltages undergo total phase shifts up to several hundred degrees, depending on frequency, the difference in phase shift between the two outputs is approxi-

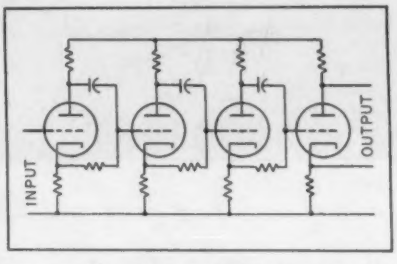


FIG. 3—Three-lattice A or B phase-shift audio network

mately 90 degrees over a very wide range. This difference can be made to extend from 50 to 5,000 cycles per second, or it may be from 250 to 25,000 cycles per second, for example.

The choice of frequencies of say 50 to 5,000 cycles per second does not mean that the phase-shift networks will not pass frequencies beyond this range (higher or lower in frequency). It means simply

(continued on p 140)

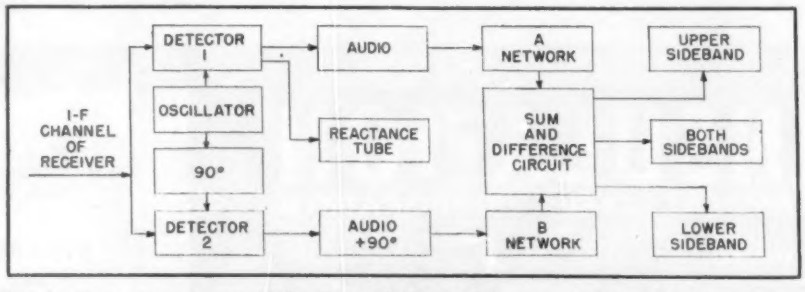
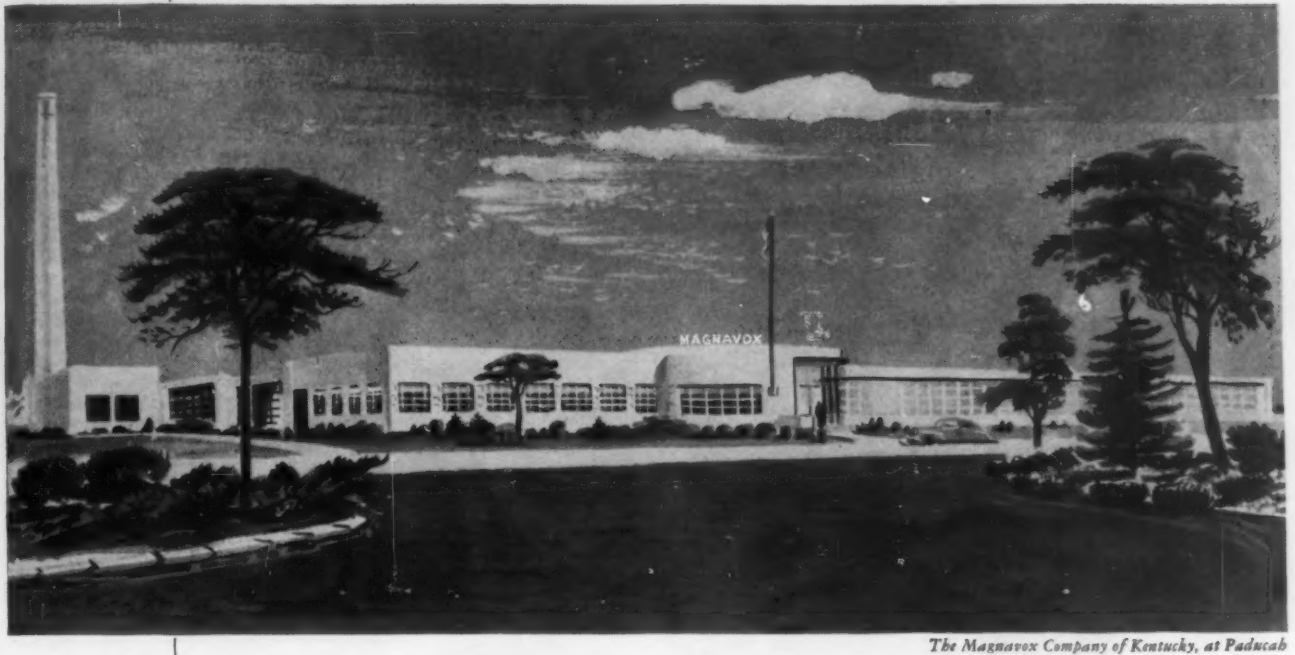


FIG. 2—Stage arrangement of the General Electric Selector unit for adding to a conventional communications receiver

Magnavox Opens Modern New Loud Speaker Factory In Paducah, Kentucky



The Magnavox Company of Kentucky, at Paducah

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THE ELECTRON ART

Edited by FRANK ROCKETT

Properties of Electromechanical 128
Measurements Made on Laboratory Model Airplane 130
Phototube Amplifier for Measuring UV Radiation 130
Electronic Camera Shutter 164
Dynamic Sound Reproduction of Harmonic Distortion 166
Oil Impregnated Capacitors 170
Survey of New Techniques 172

Properties of Electromechanical Ceramics

By HANS JAFFE

Head, Crystal Research Department
The Brush Development Company
Cleveland, Ohio

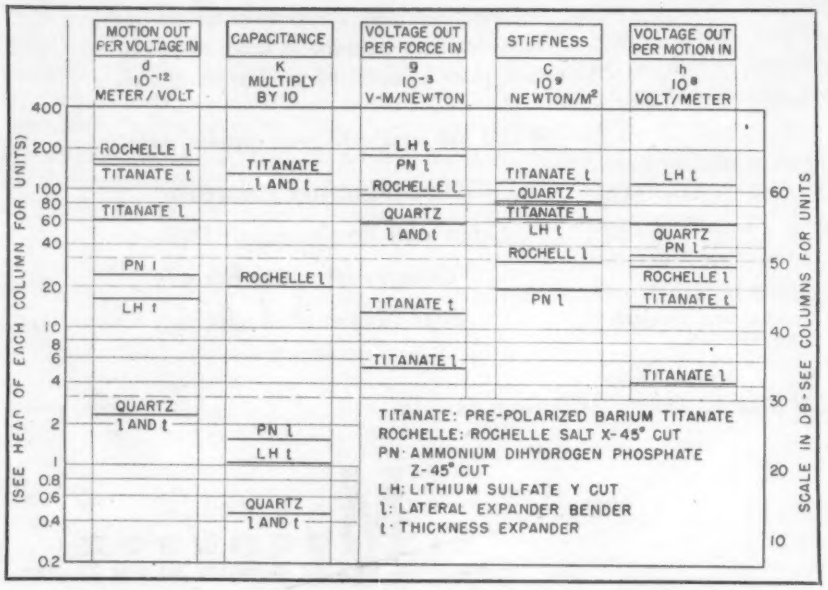
A SIGNIFICANT recent development in the capacitor field was the discovery[1] of barium titanate ceramics with a dielectric constant (specific capacity) of 1,500 which can be raised to 10,000 by the addition of strontium titanate, at the price of large variations with temperature[2]. Small single crystals of barium titanate have recently been grown and shown to be piezoelectric[3], but they are a highly refractory material melting near 3,000 F, and their commercial production seems remote. The following discussion will show that barium titanate nevertheless is a promising new material for electromechanical devices.

"Piezoelectric" Ceramics

Ordinary piezoelectricity is associated with single crystals, but in ceramic materials consisting of many randomly oriented small crystallites, a deformation proportional to the square of an applied field and a dependence of capacitance on the applied field can be expected. Usually these electrostrictive actions are minute, but in the titanate ceramics they become usefully large.

If such ceramics are maintained under electric bias they will show a linear electric response to a vibrating force and also a lienear mechanical response to an electrical signal superimposed on the d-c bias. For instance, a barium-strontium titanate plate of dielectric constant 5,000 maintained under 2,000 volts per inch raised by one-millionth of its thickness when a signal field of 800 volts per inch was superimposed over the bias field. A similar experiment carried out with essentially pure barium titanate leads to a significant result: If the biasing voltage is sufficiently high, (about 30,000 volts per inch), the medium will remain in its polarized state after the bias field has been removed[4]. It then shows a "piezoelectric" activity like a piezoelectric crystal element.

The appreciable electromechanical effects in barium titanate, in combination with its other properties, offer an inviting field for engineering endeavor. The ceramic shows a general chemical stability and resistance to moisture comparable to other good ceramics. It withstands extreme temperatures without chemical change or physical destruction. Temperatures above 250 F remove remanent polarization but higher temperatures can be used in constructing transducers before they are polarized. Unfor-



Comparison of electrical and mechanical properties of piezoelectric materials

TECHNICAL BIBLIOGRAPHIES

Bibliographies of technical subjects are available from several sources. These bibliographies can save much time in making literature searches and in conducting investigations related to other work the results of which have already been published.

A pool of unpublished bibliographies has been collected by the Special Libraries Association. These bibliographies, compiled by technical librarians, are on diversified subjects in both scientific and engineering fields. A complete list can be obtained from R. H. Hopp, chairman of the SLA Bibliography Committee, at the Battelle Memorial Institute (Columbus, Ohio) where the bibliographies are housed; he is also interested in other unpublished bibliographies that could be included in the pool.

The Office of Tech. Services, U. S. Dept. of Commerce (Washington, D. C.) has available a 1,200 item bibliography and index of reports based on field investigations of German science and industry (PB-86000, mimeographed $5.00), a 523 entry bibliography of declassified American and British reports on atomic energy (PB-87782, mimeographed $0.75), and numerous other bibliographies, which are available free of charge, on such subjects as ceramics, infrared devices, magnetic wire and tape recorders, pyrometers, and selenium rectifiers.

The Engineering Societies Library (New York City) and other technical libraries make literature searches and compile bibliographies on order as a regular part of their service to industry. Such bibliographies provide a key to the wealth of knowledge that has been accumulated in recent years.

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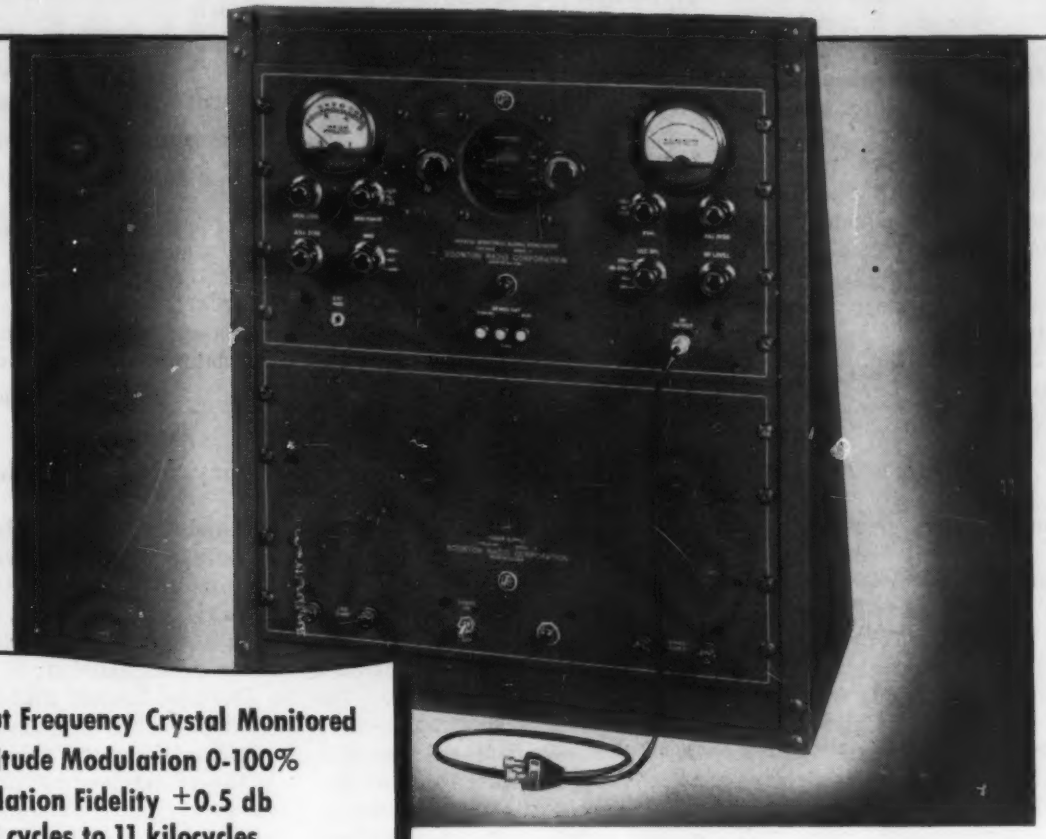

Output Frequency Crystal Monitored
Amplitude Modulation 0-100%
Modulation Fidelity ±0.5 db
30 cycles to 11 kilocycles
Negligible Spurious FM

SPECIFICATIONS

FREQUENCY RANGE: Master Oscillator: 88-140 megacycles in one range. Vernier frequency dial has 100 divisions and is coupled to the main tuning capacitor through a 120:1 gear drive. Each vernier division is equivalent to a 10 kc. change in frequency.

Crystal Controlled Frequencies: Either of two crystals 110.100 mc. and 114.900 mc., accurate to ±0.0035%, may be selected by a switch for use individually or in combination with the master oscillator to standardize its output frequency.

AMPLITUDE MODULATION CHARACTERISTICS: Two amplitude modulation ranges, 0-30% and 0-100%, are provided for use with the internal oscillator or a low distortion external oscillator. Distortion is 5% or less at 95% amplitude modulation.

Internal Audio Oscillator: Two modulating frequencies, 400 and 1000 cycles.

Modulation Amplifier: The internal modulating amplifier has the following characteristics:

Uniform response within ±0.5 db. 30 cycles to 11 kc.
Uniform response within ±0.1 db. 90 cycles to 150 cycles.
Uniform response within ±0.1 db. 9500 cycles to 10.5 kc.

Phase Distortion: (up to 60% amplitude modulation.)

Less than 0.25 degrees at 30 cycles.
Less than 10 degrees at 11 kc.

AUDIO TEST VOLTAGE: This instrument contains a demodulator or detector which supplies to front panel terminals a portion of the demodulated carrier.

SPURIOUS FM: Less than 1 kc. at 60% AM.

OUTPUT ATTENUATOR: Single ended piston type, adjustable from 0.2 volt to 0.1 microvolt. Output impedance as seen looking in at terminals of output cable is 26.5 ohms.

The Type 211-A Signal Generator is specifically designed for the testing and calibrating of omni-range radio receiving equipment. It is also well suited for laboratory and development work where a precision type amplitude modulated R.F. signal source is required.

Careful consideration has been given to the location of panel controls with respect to function and degree of use. The main frequency dial is located in the center of the panel, with the vernier dial to the left in close proximity, utilizing the same fiducial for simplicity and ease of operation. Symmetrically located to the right of the frequency dial is the output attenuator dial, directly calibrated in microvolts. The center panel enclosure embodies those controls which the operator will have the greatest occasion to use, permitting rapid, accurate settings to be made with maximum convenience.

The calibration accuracy of the frequency dial settings is ±0.25% at any point; however since crystal controlled frequencies are also available within the instrument, zero beats may be obtained from which the output frequency may be standardized to an accuracy of about ±0.025% by slipping the vernier frequency dial with respect to the main frequency dial. This feature permits the identification and checking of channel frequencies differing by as little as 100 kc.

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tunately the material is rather fragile in thin shapes.

Comparison of Piezoelectrics

Polarized barium titanate has two important piezoelectric modes. One is a compressional mode parallel to the electric field suitable for producing and detecting ultrasonic waves much as quartz X-cut. The other is a lateral compression mode which can be used in bending assemblies similar to Rochelle Salt bender.

The diagram gives operating values referred to unit size of fully polarized barium titanate compared to crystals now in use. In current output for a given applied force barium titanate is ahead of quartz by a factor 70, but in open-circuit voltage it is lower by a factor of five. Rochelle salt is ahead of barium titanate in all three piezoelectric coefficients shown, but the gap is rather small in open-circuit voltage output for given motion input, as in a phonograph pickup with good mechanical coupling. Design of titanate transducers must take account of these properties. A phonograph pickup element for instance should be made narrow to balance the high stiffness coefficient. The high dielectric constant assures adequate capacitance.

Novel shapes of transducers not procurable from conventional crystals may be made of barium titanate by forming before firing[5].

Much remains to be learned about the control and the stability of the titanates as transducer materials, but they are on their way to become an important addition to the family of piezoelectric materials.

(1) Titanium Alloy Mfg. Co., Electrical Reports No. 8, 9 (1942) and 10 (1943) by E. Wainer and co-workers.

(2) A. von Hippel R. G. Breckenridge, F. G. Chesley, L. Tisa, *Ind. Engr. Chem.*, p. 1097, 38, 1946.

(3) B. Matthias, *Nature*, p. 325, Feb. 1948.

(4) S. Roberts, *Physical Review*, p. 890, 71, 1947.

(5) W. L. Cherry, Jr., and R. Adler, *Physical Review*, p. 981, 72, 1947.

Phototube Amplifier for Measuring UV Radiation

By C. M. Rively

Vapor Lamp Engineering
Lamp Engineering Dept.
Westinghouse Electric Corp.
Bloomfield, N. J.

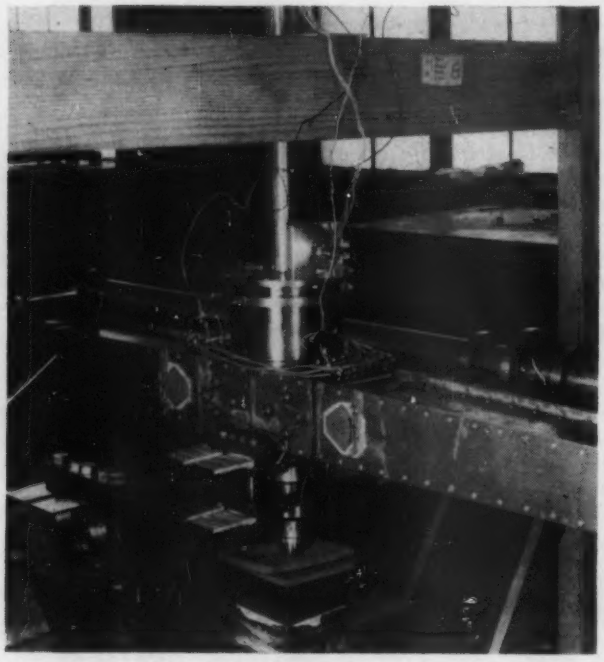
In quality control of ultraviolet lamps and in grading quartz tubes and flats for transmission, the radi-

(continued on p 162)

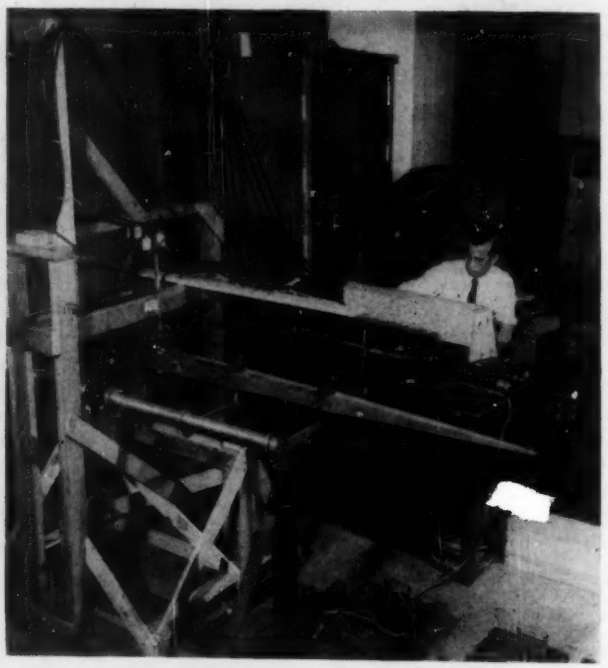
Acceleration and Strain Measurements Made on Laboratory Model Airplane

Vibrations in airframes are difficult to evaluate; it is not certain whether they are responsible for failures in wing and tail assemblies or not. Small aircraft are designed by being treated as rigid bodies. However, the transient vibrations excited by landing impact and which involve the many natural modes of vibration of the airplane are so violent in large aircraft that their flexibility must be taken into detailed account in their design.

To bridge the gap between theoretical analysis of simple structures and practical experience with actual aircraft, measurements on simplified models under controlled conditions are being made. The models consist of small scale structures that simulate the essential mechanical elements of an airplane: long flexible wing loaded at several points with massive fuselage and engines. Models are made to have a similar distribution of mass and flexural rigidity as existing airplanes. The model is released from a support that holds it in a strain free condition; it falls onto a simulated landing field to produce the impact. Strain gages and electronic accelerometer tubes mounted on the model produce signals that can be compared to similar values from theory and experience.

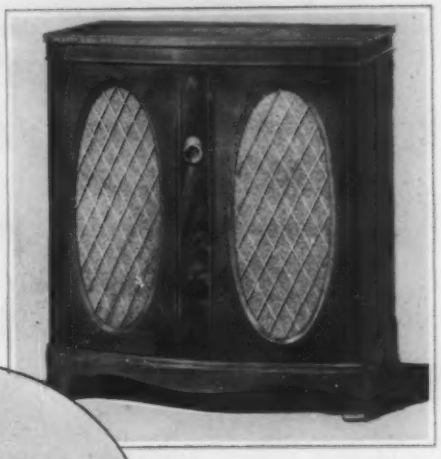


Acceleration tube, base of which can be seen projecting from its support, and gages attached to sides of simulated wing record vibrations produced by landing impact

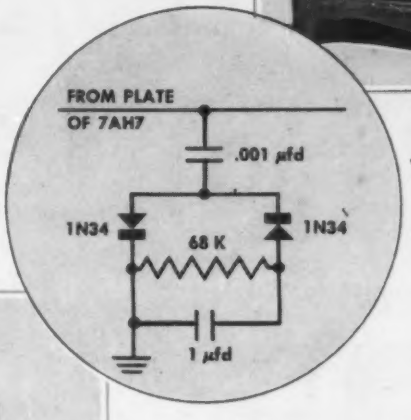


Effects of impact produced in model plane when its landing pin strikes rubber pads representing the airfield are being measured by Walter Ramberg at the National Bureau of Standards

Sound Gate lengthens range of *Bendix* FM Radio 1217-D



Circuit uses two Type 1N34 SYLVANIA germanium crystal diodes to divert overstrong signals from nearby transmitters



THE ABOVE RECEPTION RANGES SHOWN FOR ORDINARY INSTALLATIONS OF BENDIX FM RADIOS HAVE BEEN INCREASED FOR MODEL 1217-D

Advanced engineering design gives the Bendix Model 1217-D FM a range extending far beyond normal reception limits.

An important factor in this extended range is a Sound Gate circuit utilizing two Type 1N34 Sylvania Germanium Crystal Diodes. This circuit functions to divert over-strong signals from nearby FM transmitters and permits higher sensitivity for efficient reception from more distant stations.

The Bendix Sound Gate is one of many novel circuits developed to improve equipment performance or simplify design—through the use of Sylvania Germanium Crystals. Sylvania has prepared a catalog giving complete specifications on diodes and duo-diodes; a booklet of circuit suggestions made by "hams"; and two Engineering News Letters on usage and applications. This literature is yours for the asking.

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Gentlemen: Please send me your literature on Germanium Crystals.

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NEW PRODUCTS

Edited by A. A. McKENZIE

New equipment, components, tubes, testing apparatus and products closely allied to the electronics field. A review of catalogs, handbooks, technical bulletins and other manufacturers' literature

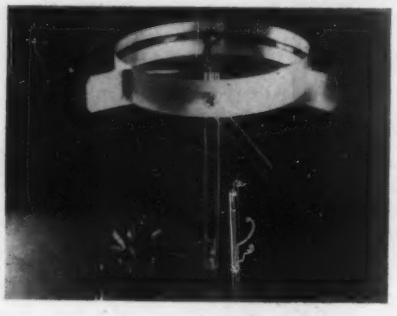
Television Generator

HICKOK ELECTRICAL INSTRUMENT Co., 10527 Dupont Ave., Cleveland 8, Ohio. Model 610 television generator enables the operator visually to align receivers to any of the present channels from 44 to 216

mc, also to align i-f stages and to insert an accurate marker at any point along the i-f response curve. Self-contained marker frequencies are directly calibrated on a 9½-inch dial.

Indoor T-V Antenna

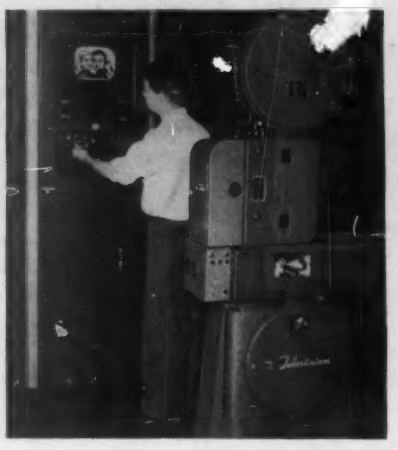
BURNETT SERVICE Co., 178 W. 168th St., New York 52, N. Y. The Visibeam is a newly developed indoor television antenna now available for use with all television receivers. The unit is 12 inches in diameter



and is made of polished lucite. It is tunable to all stations.

Projector Assembly

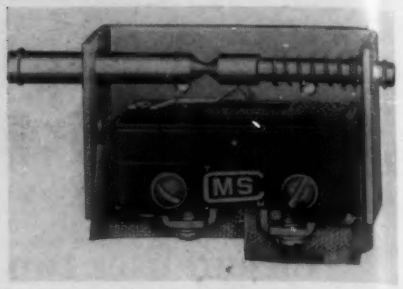
RADIO CORP. OF AMERICA, Camden, N. J. Type TP-35A sound motion picture projector employs an electronically-triggered, high-intensity "gap-lamp". The periodic lamp flashes coupled with a special film



drive mechanism make it possible to project 35-mm pictures directly on to the pickup tube of a television film camera for conversion to video signals. Monitor and change-over control are housed in a standard cabinet rack.

Cabinet-Door Switch

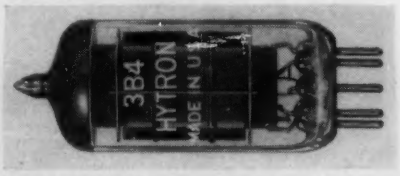
MICRO SWITCH, Freeport, Ill. The type 1AC1 interlock door switch, designed for use on h-f radio equipment cabinets, and all types of electronic controls, is single pole double throw. It automatically cuts off the power circuit when the cabinet door is open. Switching element is of the leaf actuator design. Circuit can be closed manually for



equipment servicing without hazard of forgetting to reposition the switch for normal protection.

Beam Power Amplifier

HYTRON RADIO & ELECTRONICS CORP., 76 Lafayette St., Salem, Mass. Type 3B4 is a miniature beam pentode for use in vhf portable mobile equipment as a Class-C



oscillator, frequency multiplier and r-f amplifier where it is desired to eliminate filament drain during standby periods. It employs a 1.25 or 2.5 volt filament for instant-heating and can be used at full ratings to 100 mc. Bulletin E-133 gives complete technical data.

Panel Instruments

GENERAL ELECTRIC Co., Schenectady 5, N. Y. Designed for better readability, the type DO-71 line of 3½-inch internal-pivot panel instruments are suitable for use in radio,

B-36A's are equipped with M-H's E-6 Autopilot Amplifiers Using RAYTHEON 2C50 and 2C52 Tubes

B-36A is the new U.S.A.F.—Consolidated Bomber—The World's Largest.

M-H is, of course, Minneapolis-Honeywell Regulator Company, makers of the famous MH Control Systems. Their Aeronautical Division provides the Autopilots for the B-36A's.

Type 2C50 is a low mu double triode used as the output tube in servo-amplifiers which control small reversible motors or relays. Low mu and ample cathode area permits higher currents at lower operating voltages and simplifies impedance matching. Voltage breakdown at high altitudes is reduced by ample spacing between leads in both the Raytheon Bantal® stem and melamine base which has barriers between pins.

Type 2C52 is a high mu double triode used as a voltage amplifier in this equipment.

Minneapolis-Honeywell uses RAYTHEON 2C50 and 2C52 Tubes for control operations because these tubes feature reliability and stability as a result of proven design and careful manufacturing control including:

1. Operation of every tube for several days as a routine part of the manufacturing process.
2. Use of the Raytheon Bantal® construction features a flat glass button stem, standard Dumet metal-glass seal, and heavy stiff support wires above and below the button. This construction was pioneered in millions of Raytheon receiving tubes manufactured since 1945 and has been adopted for many military ruggedized tube types.
3. Careful welding technique combined with internal mechanical features such as grid side rod clips, tungsten heaters, and mica eyelets on plate side rods, provide the extra strength needed for reliable aircraft service.

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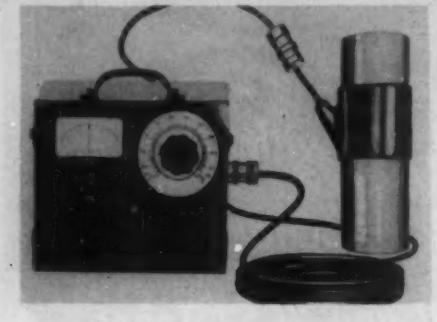
power supplies, transmitters, amplifiers and aircraft. High torque, provided by a high-strength Alnico magnet, makes for quick and accurate following of voltage and current changes.

Electronic Scale

BAKER OIL TOOLS, INC., P. O. Box 2274 Terminal Annex, Los Angeles 54, Calif. Model 500A electronic weight indicator is designed for measuring any operation in which



the tension load does not exceed 75 tons nor the compression load 150 tons. It operates on the null balance principle and translates electrical impulses into weight readings within 2 percent of full-scale load.

Eight-Pillar Tubes

RAYTHEON MFG. CO., Newton, Mass., has announced a new series of Bantal tubes with a 8-pillar support construction. Other engineer-

ing features are wide lead spacing, glass-to-glass seal, standard octal base and short leads direct to base pins.

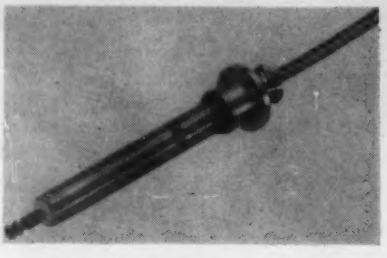
Midget Mike

RADIO CORP. OF AMERICA, Camden, N. J. The type KB-2C miniature velocity microphone shown on the left weighs only 12 ounces and fits

in the palm of the hand, making it ideal for use at remote pickups. A built-in swivel permits tilting forword or backward through an angle of about 30 degrees.

Thermocouple

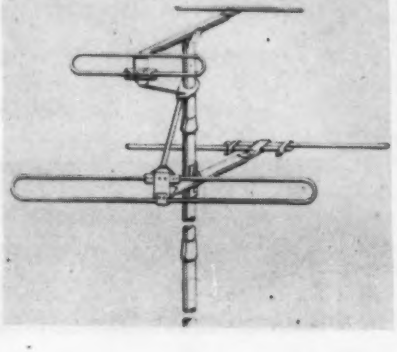
MANNING, MAXWELL & MOORE, INC., Bridgeport 2, Conn., introduces a new thermocouple for gas turbines. Time constants of better than 1.2



seconds are measured at gas velocities of 250 feet per second, with a life expectancy of 200 hours at 1,600 F.

Sectional Antenna

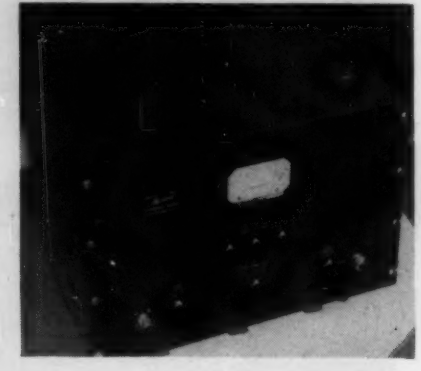
TECHNICAL APPLIANCE CORP., Sherburne, N. Y. Type 465 television antenna comprises a low-frequency



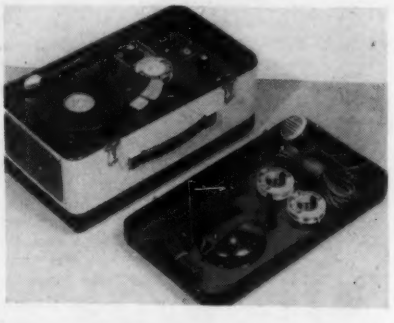
folded dipole and reflector assembly surmounted by a smaller high-frequency similar assembly, both mounted on a sectional aluminum tubular mast and connected together by a quarter-wave connecting link. High and low band antennas can be oriented independent of each other.

Wattmeter Bridge

SPERRY GYROSCOPE CO., Great Neck, N. Y. Model 123A is an automatically self-balancing and direct-reading bridge for indicating microwave power measured by a barretter element over a range of 10



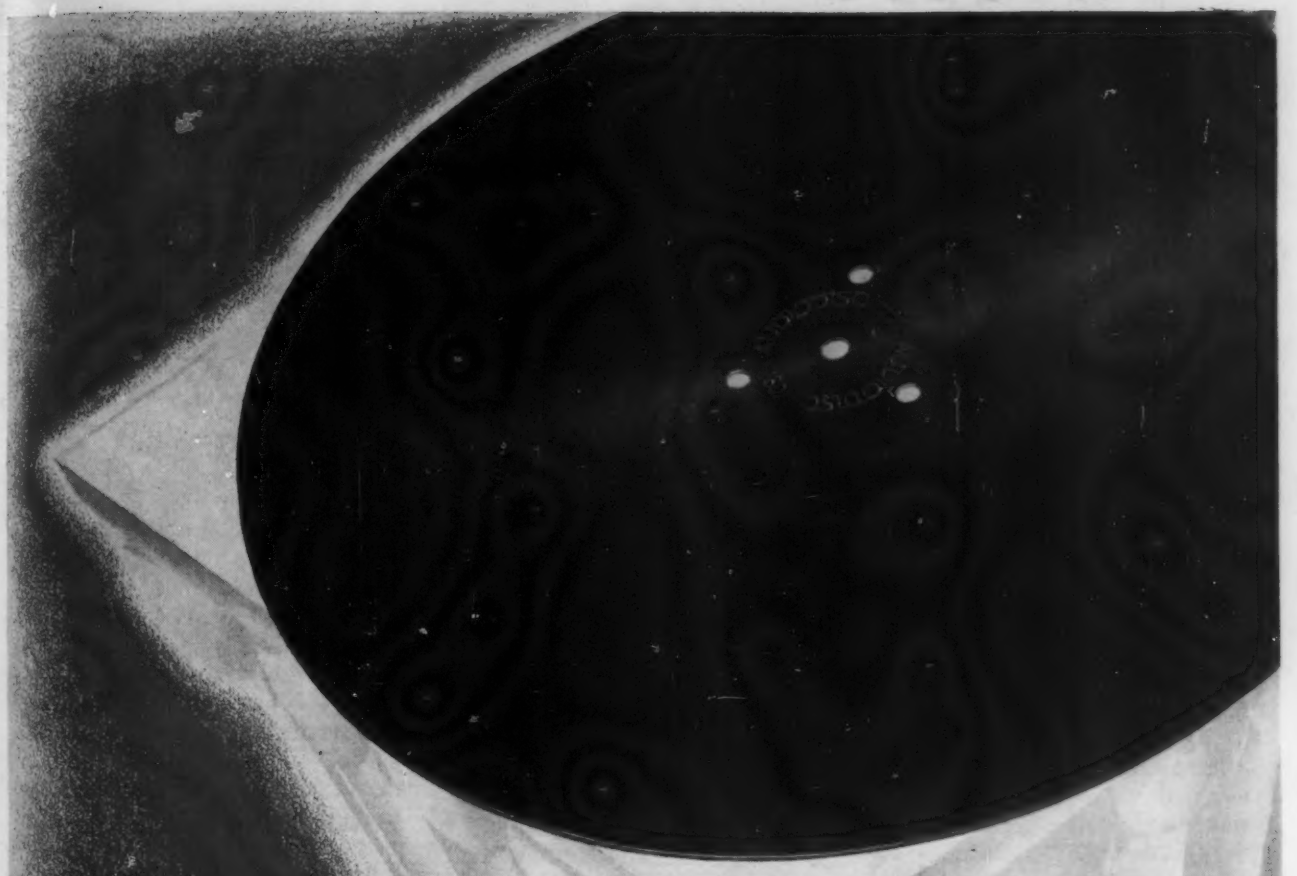
milliwatts down to a few microwatts. The unit requires 115 volts, 60 cycles for operation. Weight is 45 pounds. Descriptive literature is available.



Wire Recorder

SEARS, ROEBUCK AND CO., 925 South Homan Ave., Chicago 7, Ill., have introduced the Silvertone general-purpose portable wire recorder. It features an adapter that permits the recordings to be made and played back in conjunction with a console radio. Weight is approxi-

(Continued on p 174)



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NEWS OF THE INDUSTRY

Edited by JOHN MARKUS

New plants; new businesses; personnel moves and changes; nine book reviews and seven abstracts of new books

Television Channel No. 1 is Deleted by FCC

PREVIOUS NOTICES by the FCC concerning proposed television channel rules became effective as of June 14, as follows:

(1) Abolition of the sharing of television channels by certain non-broadcast services because of interference problems.

(2) Channel No. 1 (44-50 mc) is deleted and assigned to non-government fixed and mobile services which were sharing channels.

(3) The 72-76 mc band is allocated to the fixed services on condition that no interference is caused to television.

In consequence the Commission proposes to revise the table of allocations of the 12 remaining television channels to service areas throughout the nation. It has also ordered a judicial hearing beginning Sept. 20, 1948 in the matter of utilizing frequencies in the 475-890 mc band for black and white and/or color television broadcasting.

Laboratory Tower Dedication

A 300-foot aluminum-sheathed tower for microwave experimentation was formally opened by Federal Telecommunication Laboratories in Nutley, N. J. on May 19. Rising 358 feet above sea level, the top of the structure overlooks the main laboratory building and has a horizon that varies between 5 and 35 miles.

With 75 percent of the weight concentrated above the 212-foot level it was necessary to anchor the main column in a 10-foot reinforced concrete mat. The uplift loads, estimated to run into several hundred tons during high winds, are carried by reinforced tension cylinders extending 30 feet below the foundation mat into bedrock.

Among the developments demonstrated on the tower were a high-resolution radar with antenna rotational speed of 1 rps, together with a two-color display of reflected echoes and racon signals. A blue-fluorescent tube is used for the beacon return and an optical multiplexer shows this signal against a yellow background that represents the conventional radar return.

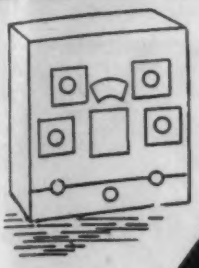
E. M. Deloraine, Technical Director of IT&T, summarized the advantages that accrue through the use of microwave links, some using ptm multiplexing, for television, telephone, and telegraph communication. By means of a prepared map he traced a possible microwave network westward through the Orient to Europe from the eastern seaboard of the United States.

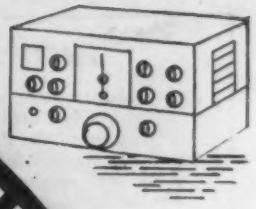
Tower for experiments in television, microwave communication, and electronic aids to navigation by Federal Telecommunication Laboratories

Basic Research Laboratory Dedicated

THE U. S. NAVAL ORDNANCE TEST STATION at Inyokern, California, in the heart of the Mojave desert, recently dedicated the huge new Michelson Laboratory honoring the late American physicist and Nobel prize winner, A. A. Michelson. Said to be the most complete basic scientific research facility of its type

Engaged in research on the physics of the upper atmosphere, C. T. Elvey is shown at work in the Navy's new air-conditioned super laboratory in the heart of the Mojave desert





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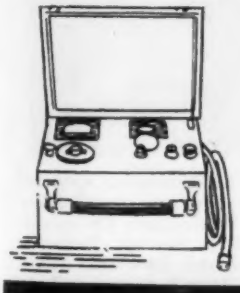
. . . **If** trustworthy, confidential collaboration is a highly necessary factor...

THEN **Lavoie Laboratories can be of invaluable, practical assistance. We have the Engineering Staff—the shop techniques—and the reputation to satisfactorily meet those requirements.**



• We shall be very glad to discuss any phase of UHF work with you. No cost or obligation involved. A resume of LAVOIE facilities may be had if you will address us on your letterhead.

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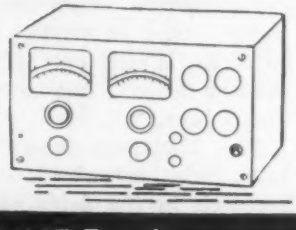
RADIO ENGINEERS AND MANUFACTURERS
MORGANVILLE, N. J.



Specialists in the Development and Manufacture of UHF Equipment

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MEETINGS

JULY 14-16: International symposium on noise, held by the Acoustics Group of the Physical Society and the Roger Institute of British Architects, at the Royal Institute, Portland Place, London, W. 1.

AUG. 20-29: All-Electrical Exposition, Pan-Pacific Auditorium, Los Angeles, Calif.

AUG. 24-27: AIEE Pacific General Meeting, Spokane, Wash.

SEPT. 4-6: ARRL Convention, Milwaukee Auditorium, Milwaukee.

SEPT. 6-11: International television meeting, with exhibition Sept. 2 to 15, Swiss Federal Institute of Technology, Zurich. Address inquiries to Secretariat, International Television Meeting, Gloriastrasse 41, Zurich 6, Switzerland.

SEPT. 13-17: Third Instrument Conference and Exhibit, Convention Hall, Philadelphia, Pa.

SEPT. 20-23: Annual meeting, Associated Police Communication Officers, Inc., Rice Hotel, Houston, Texas.

SEPT. 27-OCT. 1: Third National Plastic Exposition, Grand Central Palace, New York City.

SEPT. 29-OCT. 2: Pacific Electronic Exhibition and IRE west coast Annual Convention, Biltmore Hotel, Los Angeles, Calif.

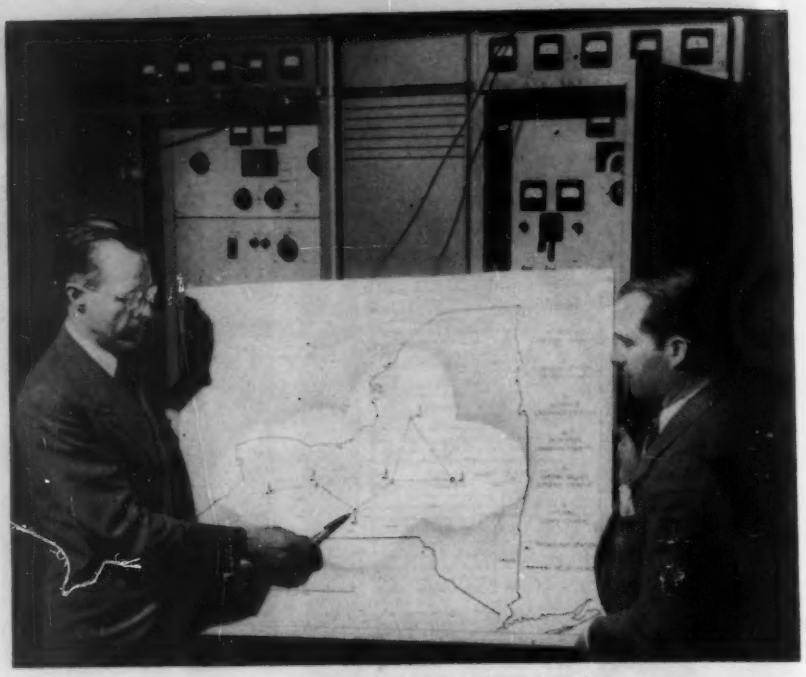
OCT. 5-7: AIEE Middle-Eastern District Meeting, Washington, D. C.

OCT. 11-12: FM Association Second Annual Convention, Sheraton Hotel, Chicago.

OCT. 25-29: 64th semiannual convention, Society of Motion Picture Engineers, Hotel Statler, Washington, D. C.

NOV. 4-6: National Electronics Conference, Edgewater Beach Hotel, Chicago.

NOV. 29-DEC. 4: 18th National Exposition of Power and Mechanical Engineering, Grand Central Palace, New York.



Before a transmitter slated for use by the network, G-E employees W. R. David (left) and W. G. Broughton discuss technical details involved in the Rural Radio Network. About 76 percent of the farms in New York State will be covered by the chain

Farmers' F-M Network

THE RURAL RADIO NETWORK, a chain of six f-m stations to serve 118,000 farms in 40 counties in upper New York State, is expected to be in operation early this summer. Most of the necessary equipment has already been shipped by General Electric Co.

Plans call for operating the six stations as a network with each station simultaneously receiving and transmitting particular programs of interest to farmers. Stations will be at Ithaca, DeRuyter, Cherry Valley, Turin, Bristol Center and Wethersfield, N. Y.

in the world, the new air-conditioned structure covers more than seven acres. Construction costs were over six million dollars.

Scientists working at Inyokern have already developed a new system of photographic analysis capable of accurately magnifying time by some four million times. This "synchronized micro-time photography," used in studies of bullets in flight, is only one of many important projects under way at the desert base.

The Michelson laboratory contains facilities for basic and applied research in the fields of physical and chemical science, aero-physics,

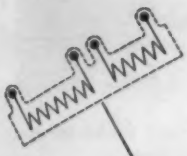
(continued on page 199)

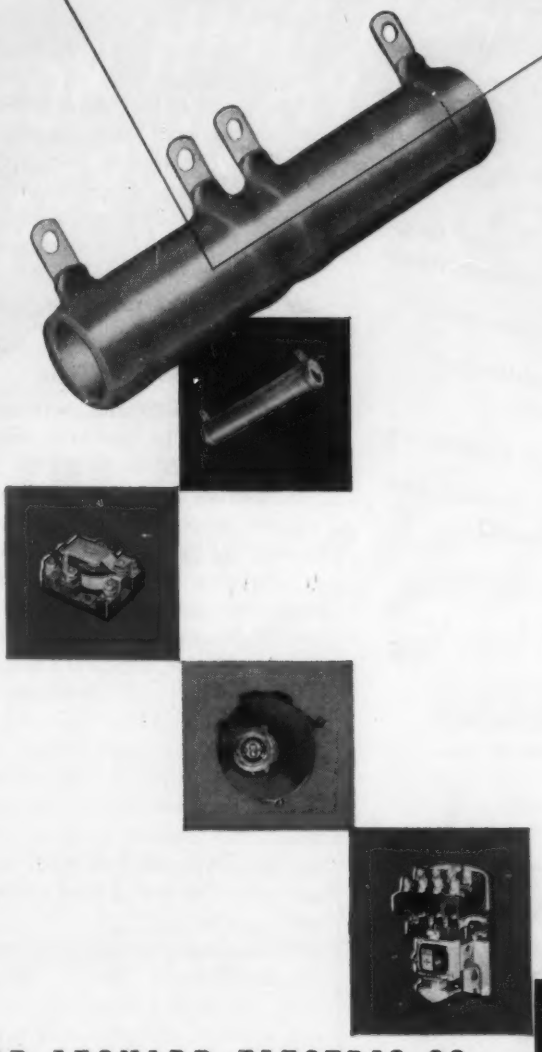
NEW OFFICERS FOR 1948-1949

Newly elected board of directors of the West Coast Electronic Manufacturers Association are, left to right, front row: Ed Grigsby, Altec-Lansing Corp. (treasurer); Wallace Walgren, Electro Engineering Works; James L. Fouch, Universal Microphone Co. (president); Noel Eldred, Packard-Hewlett Co. (secretary), and William Hewlett, Packard-Hewlett Co. (vice-president). Second row, left to right: Robert Newcomb, Newcomb Audio Products Co.; Jack McCullough, Eitel-McCullough, Inc.; John Kaar, Kaar Engineering; Lew Howard, Triad Transformer Mfg. Co.; O. H. Brown, Eitel-McCullough, Inc.; Herb Balderson, Thermador Electrical Mfg. Co.; Fred Falck Jr., Advance Electric and Relay Co.; Jim Hopkins, Girard-Hopkins Co.

IT PAYS to consider

Ward Leonard's "Result Engineering" before you specify or buy Electric Controls



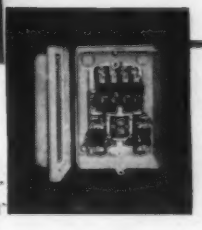


Quality construction, in a range of control devices as wide as Ward Leonard's, still may not be enough to solve *your* particular electric control problem. That's why Ward Leonard adds "Result-Engineering."

Frequently, by slight modification of a basic design or use of available components, Ward Leonard can give you the *exact* result you want —without the extra cost of a *special* design.

Here is "Result-Engineering" . . . one example of what Ward Leonard did to improve a product's performance and speed assembly: two resistors "required" for a television set were *combined* in a single unit, saving space, and cutting assembly time 40%.

Next time *you* specify or buy relays, resistors, rheostats, contactors, starters . . . before you decide to "make the best" of a "standard" component, or pay a premium for a "special", find out what Ward Leonard "Result-Engineering" can do for you.



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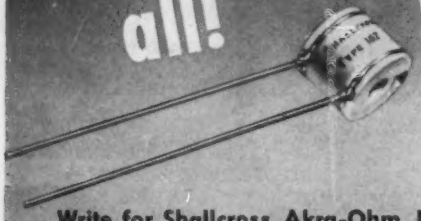

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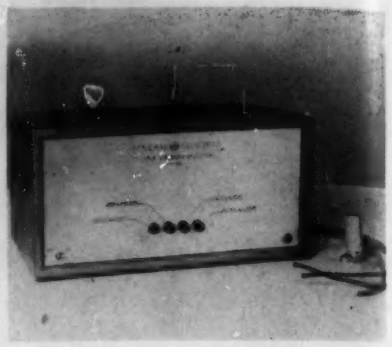

Sideband selector unit and probe for connection to the receiver

that the 90-degree phase difference is not preserved outside this range. Frequencies above or below will have a phase difference other than 90 degrees and consequently, when applied to the sum and difference circuits, they will not combine algebraically to add or cancel completely. Incomplete suppression of the unwanted sideband corresponding to these extreme frequencies is the result.

Operating Unit

A single-sideband selector unit embodying the method shown in Fig. 2 and 3 is built for use in conjunction with existing a-m receivers having a nominal i-f frequency of approximately 455 kc.

The unit is attached to the receiver by means of a small probe which is connected to the last i-f stage of the receiver through a short length of low-capacitance shielded cable. The high-impedance i-f signals are transformed to low-impedance level by means of the probe, and are then fed into the selector. The only other connections between the receiver and the unit are two shielded wires for audio.

The selector permits reception of single-sideband signals with carrier, single-sideband signals without carrier, conventional a-m signals (selecting the upper or lower sideband or both), dual single-sideband signals, that is, intelligence A on one sideband or intelligence B on the other sideband with carrier or attenuated carrier and conventional shortwave broadcasts employing exalted carrier.

Selection of any of these is done by four pushbuttons on the front panel. The phase-shift networks

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THERMO PLASTIC TUBING

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- ★ EXPANDED RANGE OF WALL THICKNESSES

REL 16-A is the new heat-resistant TURBO Thermo-plastic Tubing that provides an economical and dependable solution to most electric insulating problems involving high temperature. Approved by the Underwriters' Laboratories for continuous operation at 105° Centigrade, REL 16-A safely withstands even higher temperatures intermittently, without deterioration of mechanical or electrical characteristics. In addition to complete stability under high heat, REL 16-A tubing provides permanent flexibility—maintained under severe temperature conditions, high dielectric strength, negligible moisture absorption (less than 1%).

Typical applications in which this tubing offers important advantages over ordinary tubing include the insulation of coils and wiring where baking, potting or soldering is required; equipment with high thermal rise; enclosed units such as motors, generators, transformers, etc. Write today for complete laboratory test results, including UL reports, on TURBO REL 16-A. Samples on request.

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The solution of filter network problems, has been greatly simplified through the use of toroidal coils wound on molybdenum permalloy cores. Design engineers have learned to depend upon them since discovering that only these toroids possess all the necessary qualities of a good high "Q" coil.

Of the 30 different items now being manufactured, the most available types now being supplied are:

TYPE	RANGE
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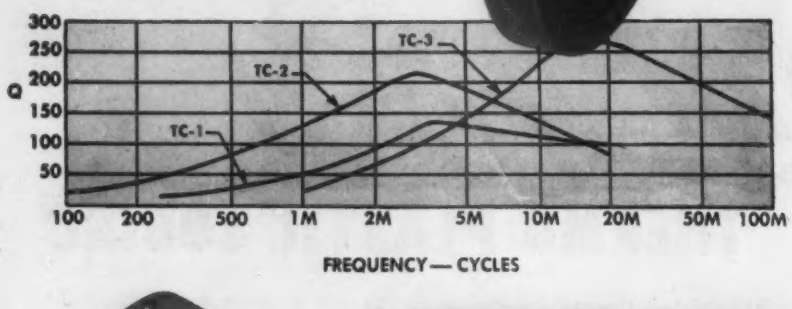
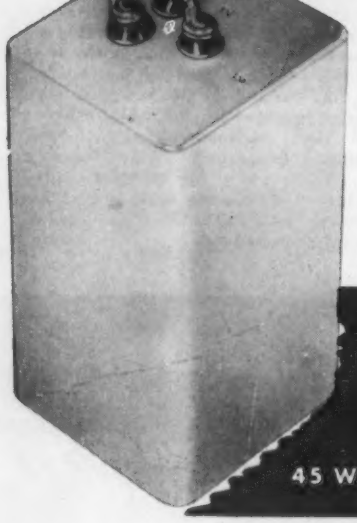
TC-2 Any Ind. up to	30 HYS
TC-3 Any Ind. up to	750 MHYS



FREQUENCY — CYCLES



FILTERS

We are producing toroidal coil filters which consistently demonstrate the value of toroidal coils. These filters cannot be matched in stability, accuracy and sharpness by filters made with the usual laminated type of coil.

Orders for samples or production quantities are equally respected. All inquiries will be promptly handled.

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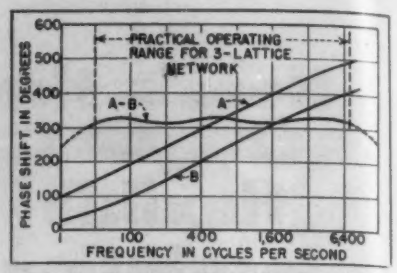


FIG. 4—Characteristics of three-lattice phase-shift network

cover a frequency range of 70 to 7,000 cycles per second. Therefore, the quality of reproduction is usually only dependent upon the i-f pass-band characteristics of the receiver.

Locked Oscillator

Should the carrier frequency delivered by the receiver tend to deviate from that of the selector's oscillator, a d-c control voltage will be delivered by the combination of oscillator frequency, intermediate frequency, and detector.

This d-c control voltage, applied in a feedback loop back to the oscillator through a reactance tube, then serves to restore the i-f carrier and oscillator to frequency synchronism. Moreover, the time constant in the d-c circuit provides the equivalent of memory; should the i-f carrier temporarily disappear because of selective fading or transmitter troubles, the locked oscillator will not get away. This is especially useful in weak-signal, transoceanic communications, and a must when the receiver is unattended over long time intervals.

This feature minimizes the need for retuning against change in transmitter frequency, change in receiver local oscillator frequency, change in selector voltages or temperatures that normally would cause frequency drift.

Satisfactory locking action is produced when the carrier of the received signal, either because of suppression at the transmitter, or because of selective fading, is as much as 20 db below sideband level. When no carrier is transmitted, no locking or control voltage is generated, so that retuning of the receiver will be necessary from time to time. For this reason a small amount of carrier, say 1 or 2 percent of the sideband energy, should

always be transmitted in single-sideband systems for use with this type of receiver.

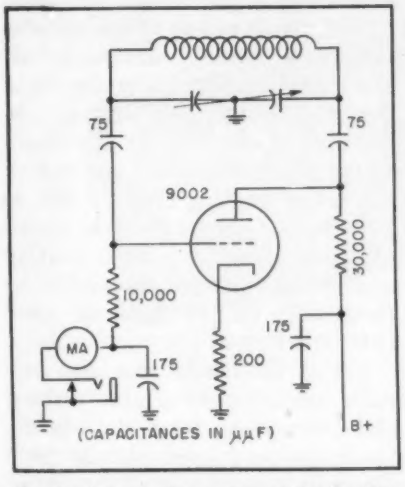
The locking circuit permits listening to a weak signal, even though a strong signal is nearby (in frequency), without the selector oscillator being captured by the stronger signal. The degree of selectivity which this makes possible cannot be fully appreciated by anything short of an actual listening test in a band of crowded signals.

Grid-Dip Oscillator

ONE of the most useful instruments in an electronic laboratory is the grid-dip oscillator with a vhf frequency range. Strangely enough, however, these have not been generally available as a commercial product until recently. Since the early days of radio, however, they have been constructed by the individual engineer to fit particular applications when needed.

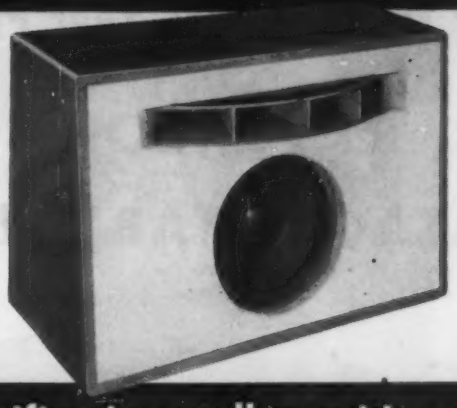
The grid-dip oscillator consists of a variable-frequency oscillator with an indicating milliammeter in its grid circuit. When the oscillator tank circuit is coupled to a second resonant circuit, usually by holding the tank inductance near the second tuned circuit, a dip in the grid current indicates the frequency at which power is drawn from the oscillator. A frequency-calibrated dial on the oscillator then indicates the frequency at which resonance occurs.

The resonant frequency of any coil and capacitor combination,



Circuit of the probe portion of the De Vine grid-dip oscillator

757A Loudspeaker



Its specifications tell you it's good . . .

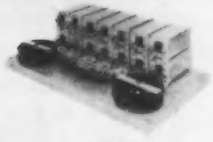
Frequency Response: 60 to 15,000 cycles.
Crossover Frequency: 1,000 cycles.
Coverage Angle: 90° horizontal: 90° vertical.
Power Input Capacity: 30 watts.
Efficiency: At distance of 30 ft. on axis, will produce a peak level of 93 db above 10^{-16} watt per sq. cm. when reproducing speech and music at 30 watts.
Input Impedance: 4 ohms (dividing network).

Its quality components say so, too . . .

728B Low Frequency Unit

713C High Frequency Unit

KS 12027 High Frequency Horn


702A Dividing Network

But to realize how good it is . . .
HEAR IT YOURSELF!

With an instrument as fine as the Western Electric 757A Loudspeaker, cold facts on specifications tell only *part* of the story. But when you listen to it yourself, you'll realize *to the full* its outstanding performance. Hear its exceptional tonal quality . . . note how faithfully it reproduces even the most complex wave-forms . . . and you'll want to use the 757A Loudspeaker wherever it's a case of bringing out the *best* in the *finest* sound systems and broadcast monitoring systems.

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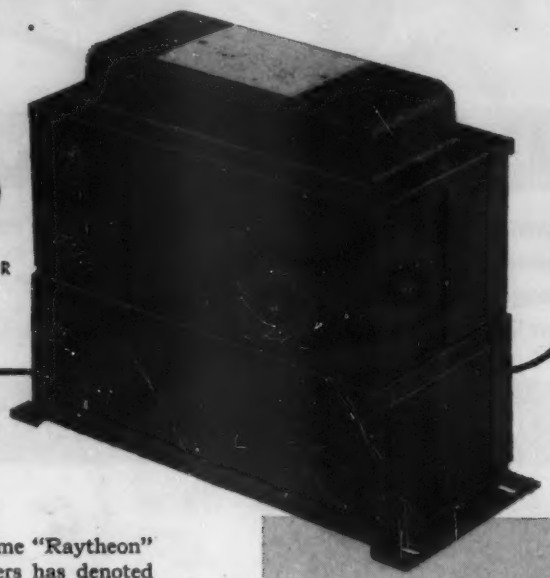

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- Entirely automatic. No adjustments. No moving parts. No maintenance.
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- Models can be supplied with frequency compensation.
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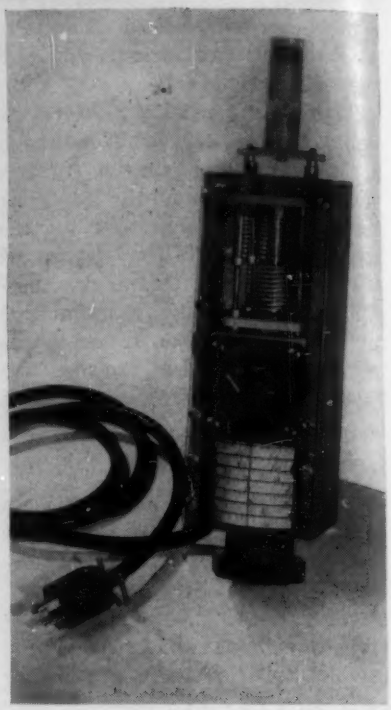

The oscillator forms a probe

alone or connected into circuits, resonant lines, wave traps, r-f chokes, and antennas, can thus be determined quickly and changes made to tune them to the desired frequency. Additional capacitance of tubes and wiring needs to be taken into account however if the unit being measured is not connected to its final operating circuit. The frequency change due to tube heating, which is particularly large at the i-f and front-end frequencies used in f-m and television receivers, can be readily determined with the grid-dip oscillator. The frequency at which wiring between components resonates may also be determined.

The circuit of one of the grid-dip oscillators recently announced by De Vine Laboratories is shown in the accompanying diagram. In addition to operation as a grid-dip oscillator it permits the addition of earphones in the grid circuit so that the instrument becomes an oscillating detector for beating against an unknown signal for determining its fundamental and harmonic frequencies.

Use of the headphones also permits operating the tube without plate voltage to form a diode detector for modulated signals from a transmitter or signal generator. Removing the headphones in this

Part illustrated, known as a transfer contact holder was transfer molded of black phenolic for International Business Machines Corporation, New York.

PRECISION IN PLASTICS

LITTLE PARTS PLAY IMPORTANT ROLES

Many of the functional elements in today's business machines are carefully thought out precision pieces — molded in plastics.

Adoption, generally, has been based upon their superior physical properties, structural strength, lighter weight . . . and also because of the molder's ability for maintaining closest tolerances and model-like quality duplication in quantity.

By proper engineering, a single plastic part often does away with extra separate parts. By integrating contact points, threaded bushings and metal inserts into the one molded piece, costly bench assemblies and hand-set fittings are completely eliminated. Thus . . . plastic parts, in themselves less costly, tend also to further lower the manufacturer's production costs.

The functional plastic part pictured here was Consolidated-molded for International Business Machines Corporation. It serves as the rear frame for a Silent Rotor Secondary Clock. Molded securely in place, as part of the one piece, are four intricately designed, specifically positioned transfer contact points. And, similarly to the many other plastic units we process for this company's highly regarded equipment, this little part plays an important role.

For your products, too, a *little* plastic may do a *lot* of good. We'd be glad for the opportunity to discuss and develop the possibilities with you. Inquiries invited!

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instance switches the meter back in the grid-cathode diode circuit and permits use as an absorption frequency meter or a field strength meter.

The instrument shown employs seven plug-in coils to cover a frequency range from 1.9 mc to slightly over 200 mc. Each coil is mounted inside a polystyrene cylinder so that it can be inserted in and near tank coils having high voltage without contact to the turns of the coil. The coils are tuned by a split-stator capacitor having specially designed plates to allow a nearly linear dial calibration in terms of frequency.

Elements of the circuit shown are mounted in a narrow metal case so that the coil, tuning capacitor, grid meter, and a drum dial are arranged in line. Thus the unit is practically a probe with its coil at one end, and dial at the other end. Having the meter mounted on this unit permits readings to be made while watching the dial when tuning through the range.

Fluoroscope Image Amplifier

A NEW high-vacuum tube electrostatically focuses and accelerates an electron stream to increase the brightness of a fluoroscope screen by 500 times.

With present fluoroscope techniques, the physician must dark-adapt his eyes for twenty minutes to see the image. If he examines a large abdominal thickness the brightness may be as low as 0.00005 millilambert, while a separation of 0.25 inch is necessary before contours between black and white can be distinguished. A brightness of 0.001 millilambert with a contour separation of 0.03 inch is about the center of the fluoroscope range.

The new image amplifier, announced by Westinghouse X-Ray Division at Baltimore, increases the brightness of the fluoroscopic image after the x-rays have passed through the patient. This technique is necessary because the x-ray intensities are already at the patient's tolerance level and is possible because the sensitivity of the physician's eyes are the main limitation to effective fluoroscopy today. Present fluorescent screens have a

They're talking about

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HEINEMANN

MAGNETIC CIRCUIT BREAKERS

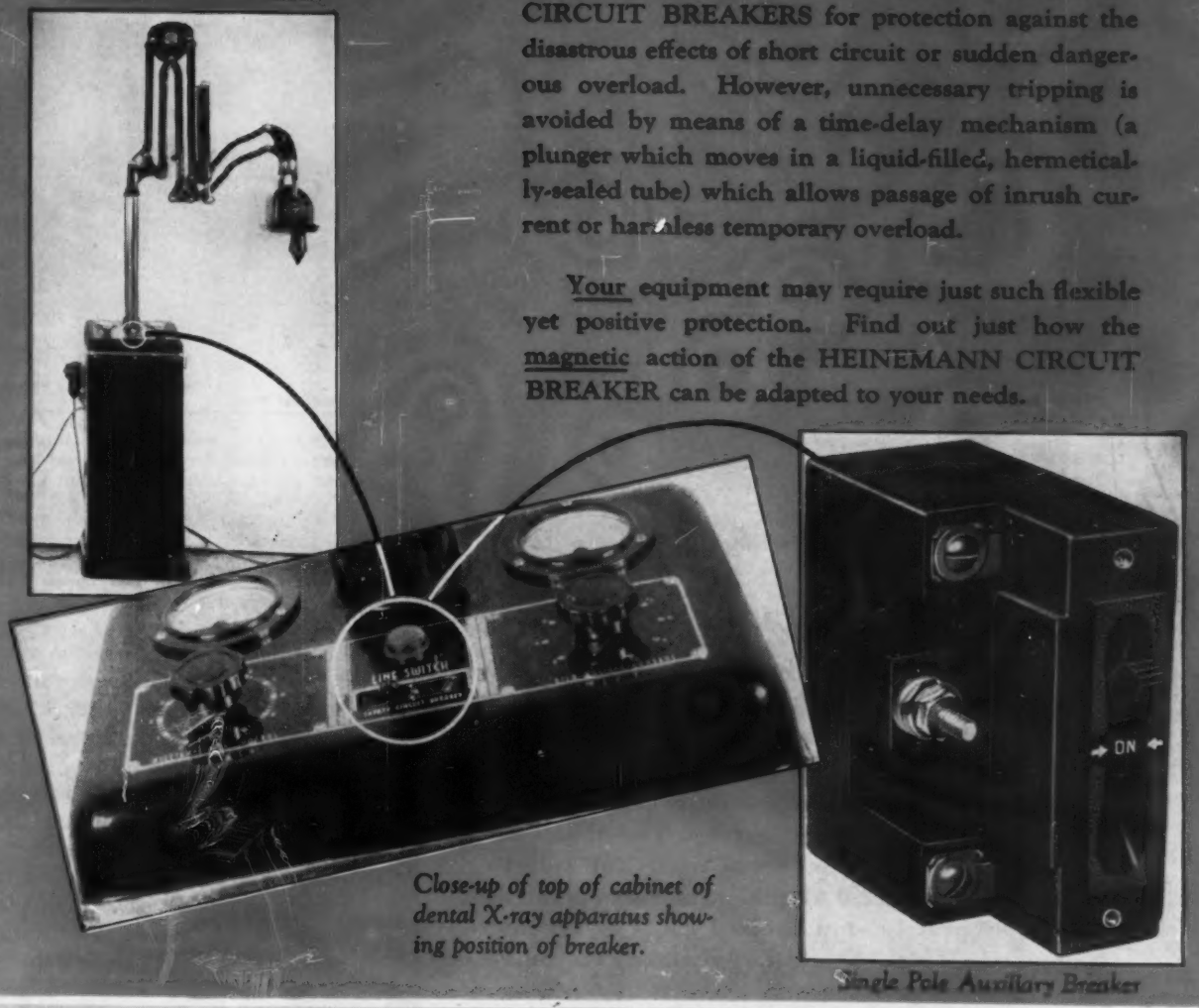
A Positive Protection for Expensive Apparatus

H. G. FISCHER & CO.

well-known manufacturers of dental X-ray apparatus, say in their descriptive folder, "The line switch is also a safety circuit breaker and is not only a guarantee of electrical and overload safety, but also prevents the line fuse from burning out."

Unfailing, instantaneous, magnetic action is the reason why manufacturers of intricate and delicate instruments depend upon HEINEMANN CIRCUIT BREAKERS for protection against the disastrous effects of short circuit or sudden dangerous overload. However, unnecessary tripping is avoided by means of a time-delay mechanism (a plunger which moves in a liquid-filled, hermetically-sealed tube) which allows passage of inrush current or harmless temporary overload.

Your equipment may require just such flexible yet positive protection. Find out just how the magnetic action of the HEINEMANN CIRCUIT BREAKER can be adapted to your needs.



Close-up of top of cabinet of dental X-ray apparatus showing position of breaker.

Single Pole Auxiliary Breaker

HEINEMANN ELECTRIC COMPANY

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with these BALLANTINE instruments

10 MICROVOLTS to 10,000 VOLTS

ONE BILLION TO ONE—This enormous range of AC voltages—is easily covered by the Model 300 Voltmeter, Model 220 Decade Amplifier and Model 402 Multipliers illustrated above. The accuracy is 2% at any point on the meter scale, over a frequency range of 10 cycles to 150 kilocycles. The Model 300 Voltmeter (AC operated) reads from .001 volt to 100 volts, the Model 220 Amplifier (battery operated) supplies accurately standardized gains of 10x and 100x and the Model 402 Multipliers extend the range of the voltmeter to 1,000 and 10,000 volts full scale.

Descriptive Bulletin No. 10 Available

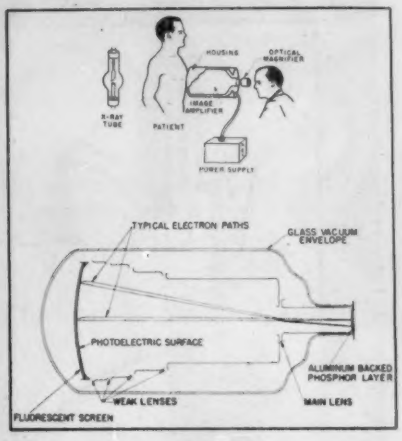
BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY, U.S.A.

gross efficiency of about three percent so that even a theoretically perfect screen would be only about thirty times as bright.

With the image amplifier tube, the physician will see at once an image almost as bright as a movie screen. He may still dark-adapt his eyes for about three or four minutes to see all the details of the patient's organs at work.

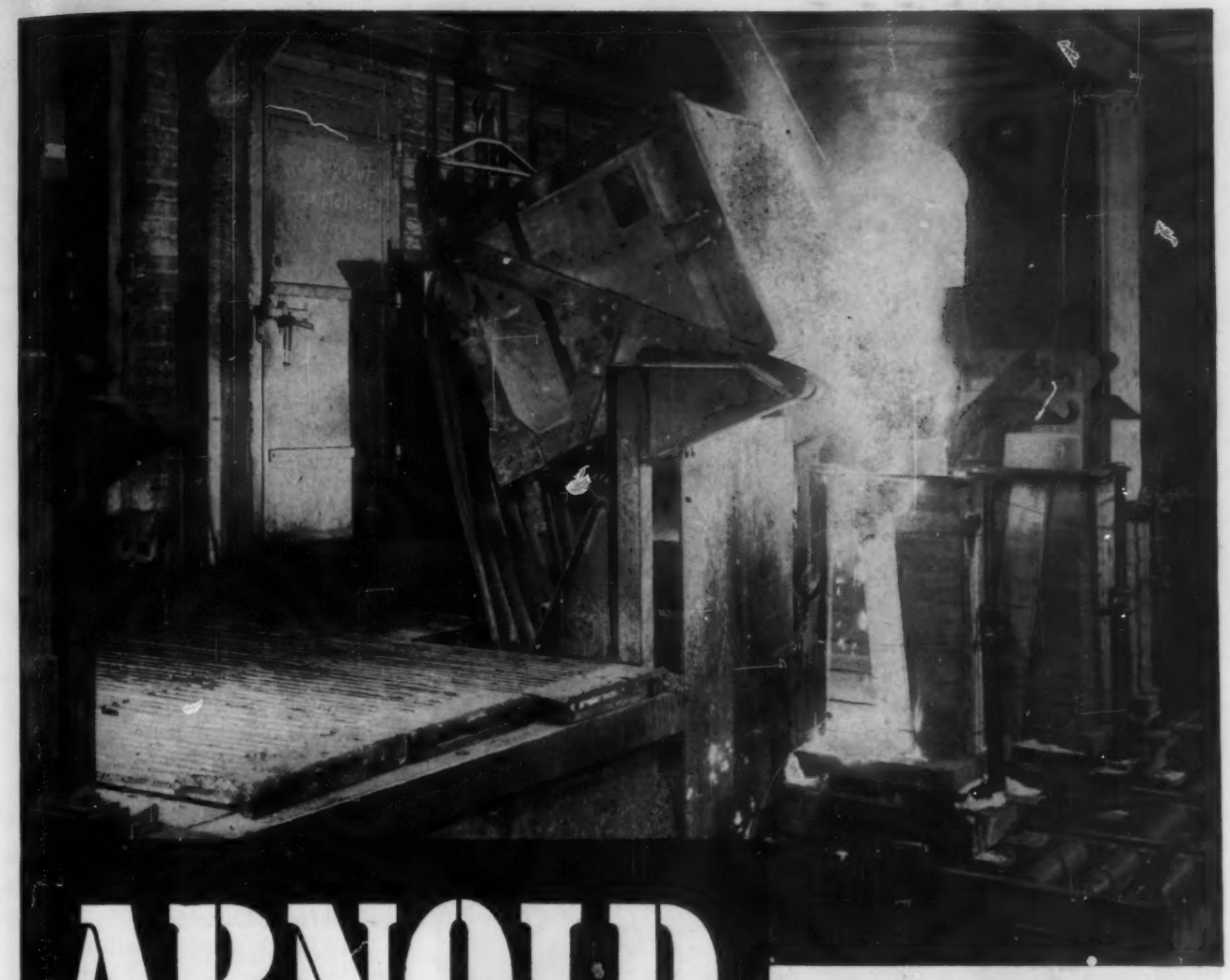
Figure 1 shows the elements of the tube used to increase brightness of the x-ray image. The x-ray quanta is converted into light with a fluorescent screen and thence to electrons by means of an adjacent photo-electric surface. These electrons are accelerated by a high



X-rays that have passed through the patient strike the fluorescent screen at left and produce light photons that eject electrons from the photoelectric surface. The electrons are electrostatically accelerated and focused to form an inverted smaller image on the phosphor at right. Optical magnification brings this image back to the original five-inch size

potential placed across the vacuum tube, giving a brightness gain of 20 times. A further factor of 25 in brightness gain is attained by electrostatic focusing of the electron stream to reduce the image to 1/5 of its size. The reduced image, now brightened 500 times, impinges on a phosphor output layer that converts it back to a visible image which is observed through a conventional optical system that magnifies it by a factor of 5 back to its initial size.

The intensification achieved by reducing the image size in the electron optical system is possible because the brightness is increased in inverse proportion to the area. This is so because all the electrons



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The increased efficiency and economy you'll realize in the use of Arnold Permanent Magnets are *constant* factors. The thousandth unit is exactly like the first—because they're produced under controlled conditions at every step of manufacture, to bring you complete uniformity in every magnetic and physical characteristic. Count on Arnold Products to do your magnet job *best*—and they're available in any grade of material, size, shape, or degree of finish you require. Write us direct, or check with any Allegheny Ludlum field representative.

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Cutaway view of the image amplifier tube. Its principle of operation is reminiscent of the Snooperscope and Sniperscope used for infrared viewing during the war

are utilized in forming the image. When the area is reduced, the total energy therefore remains constant. Thus the energy per unit area, which is proportional to brightness, must go up. The reduced image seen through an ordinary optical magnifier appears in its original size without losing the brightness gained in the electron-optical reduction.

The image amplifier will permit shorter examinations and allow use of the wafer grid, stereofluoroscopy and even televising of fluoroscopic images.

Elevator Signal Button

THE push-button era is past; now all one has to do is touch the button. Essentially, the new system developed by Otis Elevator Co. consists of a cold cathode, gas triode that replaces the conventional mechanical push-button and its associated relays. Auxiliary electronic equipment controls the elevator stopping system and provides the power supply.

Simple Signal Wiring

Among the advantages obtained by this development are: The push-button, in operating, produces an indicating light to assure the passenger that his signal has operated the equipment, and without requiring auxiliary return wires from the central control station in the motor penthouse. Because there are no

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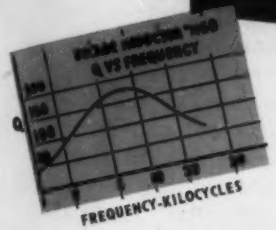
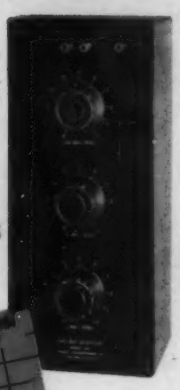
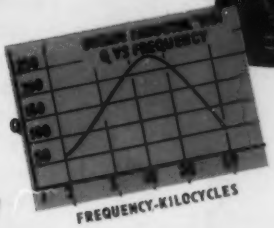
No. 1160
10 x 1 HY steps
10 x .1 HY steps
10 x .01 HY steps
500-15,000 cycles

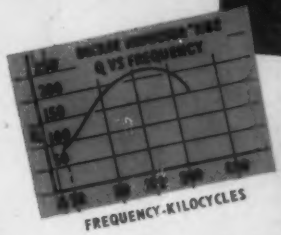




No. 1161
10 x .1 HY steps
10 x .01 HY steps
10 x .001 HY steps
2000-50,000 cycles



No. 1162
10 x .01 HY steps
10 x .001 HY steps
10 x .0001 HY steps
10,000-300,000 cycles



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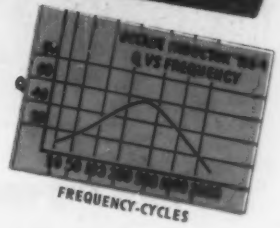
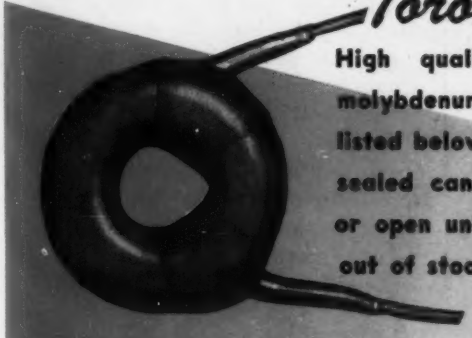
Primarily designed for use in wave filters, tuned circuits and equalizers for audio and supersonic frequencies. The stability, accuracy and high value of Q make these Decade Inductors invaluable laboratory instruments.

No. 1164
10 x 10 HY steps
10 x 1 HY steps
10 x .1 HY steps
50-1000 cycles



Toroidal Inductors



High quality toroidal coils wound on molybdenum permalloy dust cores. All those listed below can be supplied in hermetically sealed cans, commercial type construction or open units. Other types can be supplied out of stock on special orders.

Type T1 1000-15,000 cycles		Type T1-2 2000-30,000 cycles		Type T1-3 10,000-300,000 cycles	
Inductance Value	Type #	Inductance Value	Type #	Inductance Value	Type #
5 MHY	F-800T	1 MH	F-1800	5 MH	F-1850
10 MHY	F-801T	2 MH	F-1801	1 MH	F-1851
15 MHY	F-802T	3 MH	F-1802	2 MH	F-1852
30 MHY	F-803T	4 MH	F-1803	3 MH	F-1853
50 MHY	F-804T	5 MH	F-1804	4 MH	F-1854
75 MHY	F-805T	10 MH	F-1805	5 MH	F-1855
100 MHY	F-806T	15 MH	F-1806	10 MH	F-1856
200 MHY	F-808T	30 MH	F-1807	15 MH	F-1857
500 MHY	F-809T	50 MH	F-1808	20 MH	F-1858
750 MHY	F-810T	75 MH	F-1809	30 MH	F-1859
1 HY	F-811T	100 MH	F-1810	40 MH	F-1860
1.5 HY	F-813T	150 MH	F-1811	50 MH	F-1861
2 HY	F-815T	200 MH	F-1812	75 MH	F-1862
3 HY	F-819T	300 MH	F-1813	100 MH	F-1863
4 HY	F-821T	400 MH	F-1814		
5 HY	F-823T	500 MH	F-1815		

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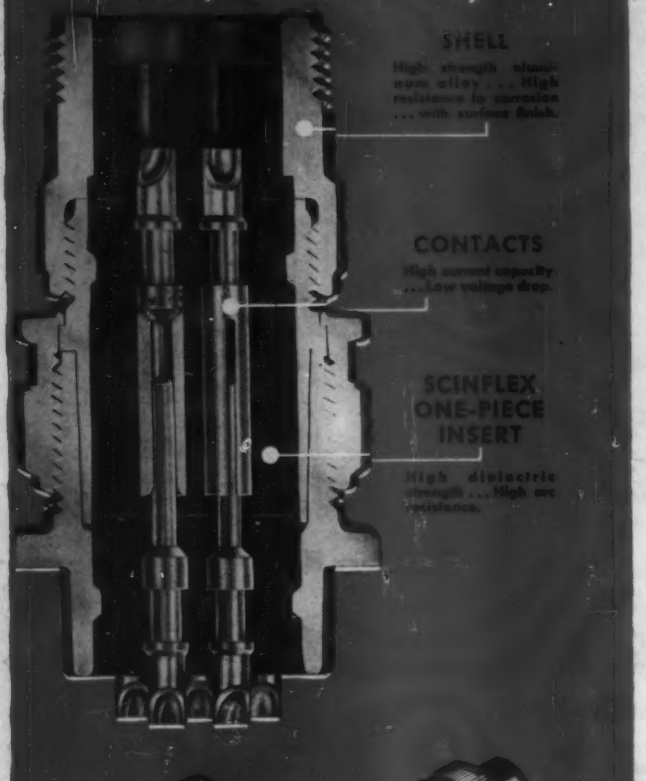

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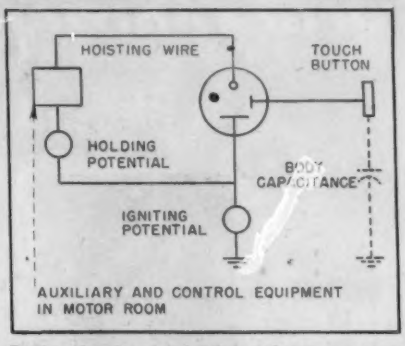

Basic circuit of electronic button: circuit values can be adjusted so that merely pointing at the button fires the tube

moving parts associated with the electronic switch, its life and protection from jamming are improved.

The electronic relays operate on potential difference, rather than on current differences as do electromagnetic relays, so cabling is not required to carry high current (although the gage of the wiring is determined by its mechanical strength which must be sufficient to withstand the strain of pulling it through the conduits during installation, rather than by its current-carrying ability). William Bruns, electrical engineer in charge of electronic development, prefers the electronic signaling system because it permits using high-impedance circuits. However the impedance that can be used across the signal lines with the electronic system is limited by the noise picked up from stray fields in the building; it is necessary to load the lines below the value determined by the electronic equipment itself to prevent false operation.

In addition, operation of electronic equipment is done by potential differences permitting a much wider variation in power supply voltages than is tolerable with relays. The limits of power supply variation with relays are set by the relay pulling in due to over-voltage thus giving false indications, and failing to pull in due to under-voltage. Similar limits exist for gas tubes, but the limits are wider. In the application to elevator signalling, a change in power line voltage from 100 to 150 volts is tolerated by the equipment. An autotransformer supplies the equipment with voltage centered in the tolerance range.

The "touch button" consists of

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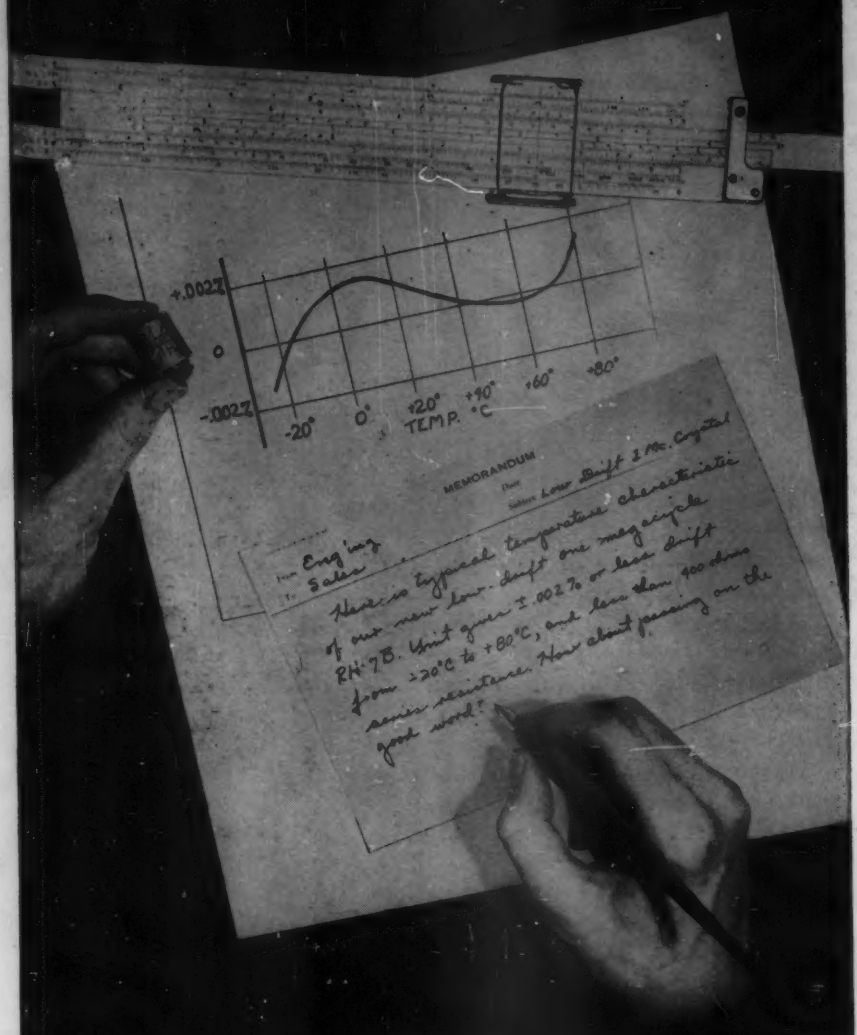
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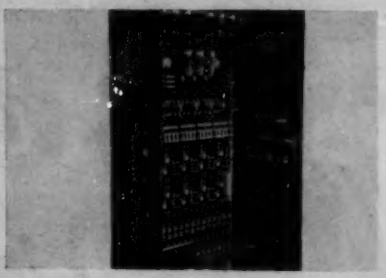

Elevator-control thyratrons and resistance-capacitance circuits are in the lower portion of the rack that houses the rectifiers (top) for the signaling system

a gas triode (similar to an 0A4G) connected as shown in the accompanying diagram. An electrode connected to the control grid is molded into the colored arrowhead of the signal button (red arrow for down, green arrow for up). When one touches the appropriate arrow, body capacitance to ground (metal building frame) closes the circuit thus triggering the tube. The tube is located directly behind the arrow. All tubes on a floor for a given direction are connected together so that touching one lights all.

When the tube fires, it establishes a potential on the floor selector controller on the elevator lift mechanism in the motor penthouse. When the floor selector contacts the potential bearing brush, it cancels the call, extinguishing the tube, and stops the elevator at the floor.

Part of the electronic control installed for the first time in the Universal Pictures Building, New York, is a time delay adjusted to start cycling every time a signal tube fires. The time delay is adjusted to the interval normally required for an elevator to stop at a floor, discharge and take on passengers, and accelerate. If no elevator is in motion after this interval (such as at night when the elevator bank is attended by the watchmen) following the firing of a tube, the time delay sounds a buzzer in the elevators to alert the operators. The time delay continues recycling until interrupted by a signal from a moving elevator.

The equipment that the electronic system replaced consisted of a bank of multicontactor relays and multiconductor cables to all floors. The gas tubes at each floor replace the relays and fewer cable pairs are required to all floors. Although

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electronic signal control is applicable to elevator installations in any building, the present installations are being made in large buildings where elevators travel at 500 feet per minute or faster.

Single-Sideband Converter

IN keeping with the current interest in single sideband reception, the circuit of the Millen adapter unit is shown in the accompanying diagram. It consists of a crystal-controlled low-frequency converter designed to adapt communication receivers for selectable single sideband reception. Eliminating one of the side bands by selection reduces interference, both from the standpoint of noise, and heterodyne signals, owning to the reduction of the normal receiver bandwidth to approximately 25 percent.

The unit consists of a crystal-controlled oscillator and a mixer which converts the normal 455-kc i-f to 50.5-kc; an i-f amplifier with four high-Q tuned circuits; a detector and audio amplifier, and a power supply. A lever-type switch mounted on the front panel switches the oscillator crystal to provide either 49.5 or 50.5 kc to select the sideband which is to be passed.

The 455-kc output from the receiver is coupled to the sideband selector by a small loop on the input cable which is slipped around the diode plate pin on the receiver detector tube. The audio output of the selector can be used directly for headphone reception or the output may be fed into the audio amplifier in the receiver for loudspeaker reception.

The normal receiver audio gain control is turned off so that the output from the receiver detector does not get into the audio amplifier. In some receivers the leakage may be such that it will be necessary to disconnect the first audio amplifier tube.

The i-f transformers T_1 and T_2 are aligned to 50.5-kc and, with the switch in the upper sideband position, the response at 50-kc is about 5-db down.

When the switch is in the double sideband position, T_2 has been retuned by capacitor A to 49.5-kc and this (plus T_1, which is still tuned

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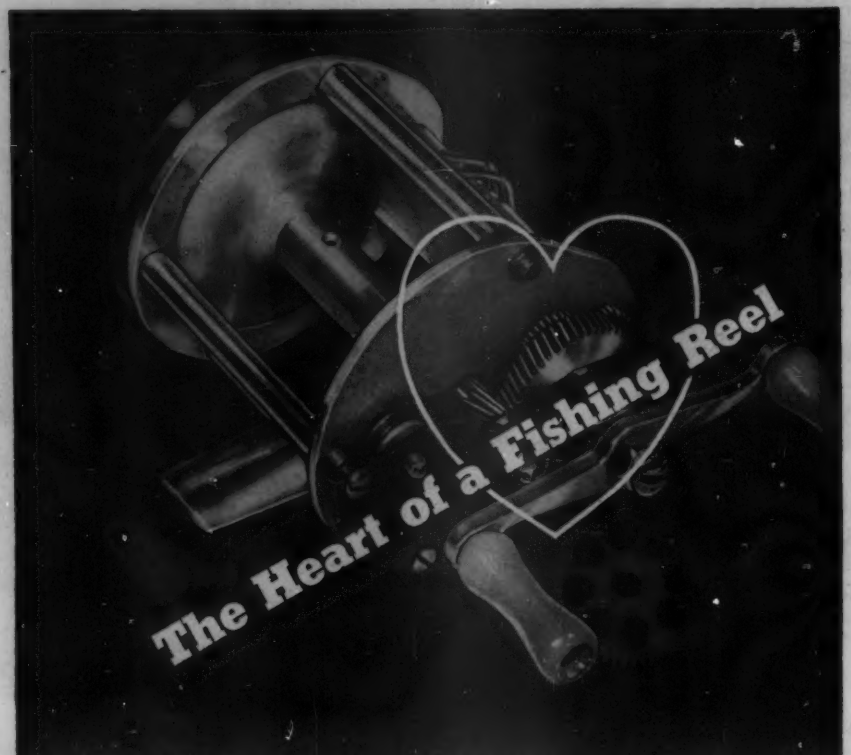

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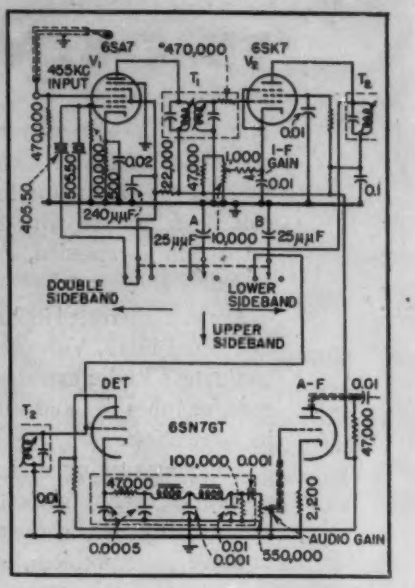

Circuit diagram of the single-sideband converter

to 50.5-kc) results in a sharp-nosed curve ideally shaped for aural carrier tuning peaked at 50-kc. This double-sideband tuning position can be used for normal operation. Its selectivity is high enough to attenuate most high-frequency heterodynes lying above 2,000 cycles.

When the interference gets bad and the off-frequency carrier gets in closer so that the beat note drops to 1,000 or 500 cycles, one of the single sideband positions is switched in, and the tuning control rocked slightly. If the heterodyne persists, the other sideband is switched in and the tuning control rocked again. For maximum rejection it is necessary to climb up slightly on the low-frequency side of the curve to a point about 5-db below the peak.

The first section of the 6SN7GT operates as an infinite-impedance detector, and the second section of the tube is used as an audio amplifier. A high-pass filter having high attenuation to frequencies below 300 cycles is installed in the audio circuit. This filter not only removes undesired low-frequency beat notes, but makes speech sound natural by attenuating the lows in proportion to the highs. It also takes out some of the noise.

X-Raying Flier Reactions

How a flier reacts physically to the strain of a crash landing or the

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An outstanding feature of this ring magnet is the very thin wall section developed by G-E process engineers. Heretofore this was possible only with sintered magnets. Better permanent magnets as well as new applications are constantly being developed by G-E engineers.

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shock of being catapulted from a crippled plane is being determined in one of the more recent uses of millionth-of-a-second x-ray equipment. Both Army and Navy medical laboratories are making sequence photographs to obtain visual evidence of what happens to a pilot's spine, heart and other organs under such conditions, according to Charles M. Slack, research director of Westinghouse Lamp Division.

In crash landings, a flier undergoes a shock equivalent to 10 times that suffered by a motorist if he could halt his machine in one second from an 85-mile-an-hour speed. Body harnesses cushion such deceleration blows, but more knowledge of the action of the body organs may be of value in further solving the problem.

At supersonic plane speeds, a pilot would be cut to ribbons by the wind if he tried to climb out, so a catapult throws him out when a button is pushed.

The high acceleration necessary to get the pilot out without his striking the plane causes a violent jolt to his organs, about 20 times as severe as the normal pull of gravity. X-ray studies of ejection-seat body bending, and studies of the proper amount of explosive force required to fire pilots out of the cockpit, are under investigation.

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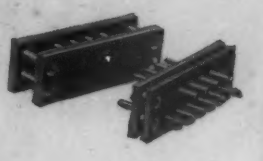

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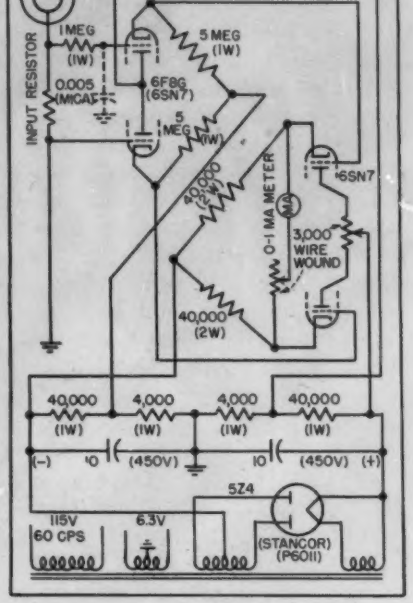

Circuit of stable current amplifier

ation is measured with a platinum, zirconium, or tantalum phototube. Current flowing through the phototube in the presence of radiation passes through a large resistance to develop a voltage output. An economic and stable current amplifier was developed for use under these conditions. It is compact and sufficiently rugged to be mounted on manufacturing machinery for quality control. The circuit is shown in the accompanying diagram.

Circuit Considerations

Because the load resistor used with the phototube is of very high resistance, the amplifier must have a high input impedance. The vacuum tube bridge circuit chosen has the necessarily high input impedance and low reverse grid current without requiring regulation of the plate supply. Gas current is minimized by keeping the plate voltage of the first stage low (about 17 volts) and by choosing proper grid bias. The load resistors in the cathode circuit make the amplifier highly degenerative resulting in a very small net change in grid voltage with signal voltage applied and a correspondingly small grid current change. The measured gas current is 75×10^{-6} microamperes, compared with the phototube cur-

rent of 500 × 10^{-6} microamperes. To obtain sufficient current to operate a 0-1 ma meter, a second stage of amplification is used.

The balanced circuit stabilizes the amplifier against changes in power line voltage. Dual triodes are used because changes are likely to affect both sections more equally than they would were each triode, in a separate envelope, and especially because the gas currents will be equal during the life of the tube. A 30 percent change in line voltage (90 to 130 volts) moves the zero setting only 4 percent of full scale.

Because voltage amplification is not needed in this application, the stability is readily obtained by

Spectral response at 1,850 and 2,537 Angstroms are measured in laboratory by placing photometer above lamps

making both stages highly degenerative. Thus a 1.5-volt input produces full scale deflection with maximum sensitivity; 6 volts produce minimum sensitivity.

Although the leakage of the 6SN7 is negligible, a 6F8G double ended tube, dipped in wax, was used to reduce possible leakage during high humidity. However, almost any double triode would be satisfactory in this highly degenerative circuit. The input resistor was sealed in a glass tube and waxed to further prevent leakage at the input. With the phototube and amplifier housed in a 6 × 9 × 5 inch cabinet, and with the input capacitor (which incidentally is another source of leakage) removed, the stability and shielding protected the equipment from disturbance by a spark-gap induction unit 10 ft away.

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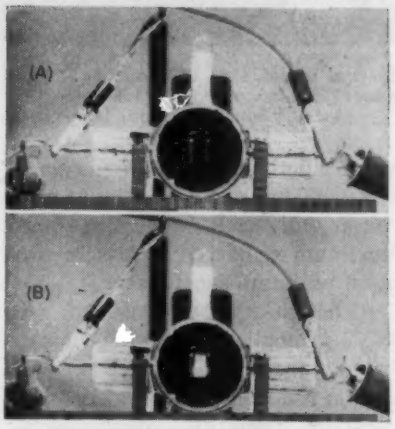
minutes warmup is about 2 percent. After an hour's warmup, the drift over 4 hours was unnoticeable. An input resistor is chosen so that, with normal radiation reaching the phototube, from 1.5 to 3 volts are produced across the input. With the phototube covered, the meter is zeroed by adjusting the balancing potentiometer. With a standard source radiating the phototube, the multiplier rheostat is adjusted to give the desired meter deflection.

With a WL-782 Sterilamp about 30 inches from a tantalum phototube, and a 500-megohm resistor, and about an inch of the arc uncovered, full scale meter deflection was obtained. With a Westinghouse RS Sunlamp and a zirconium phototube similarly placed, full scale deflection was obtained at about half sensitivity. A platinum phototube is used to measure radiation near 1,850 Angstroms.

Electronic Camera Shutter

THE FASTEST SHUTTER, capable of taking a picture with an effective exposure time of a hundredth of a microsecond, has been developed by



Normally light is blocked (A), but when voltage is applied to the cell its fluid becomes birefringent enabling the light to pass both polarizing filters (B) of this electro-optical shutter

Dr. A. M. Zarem for use in synchronized microtime photography at the Navy's new Michelson Laboratory at Inyokern, Calif. This shutter is a part of the program for precision measurement of time intervals and study of high speed phenomena.

The Zarem shutter is basically a Kerr cell mounted between crossed polarizing filters. Normally light

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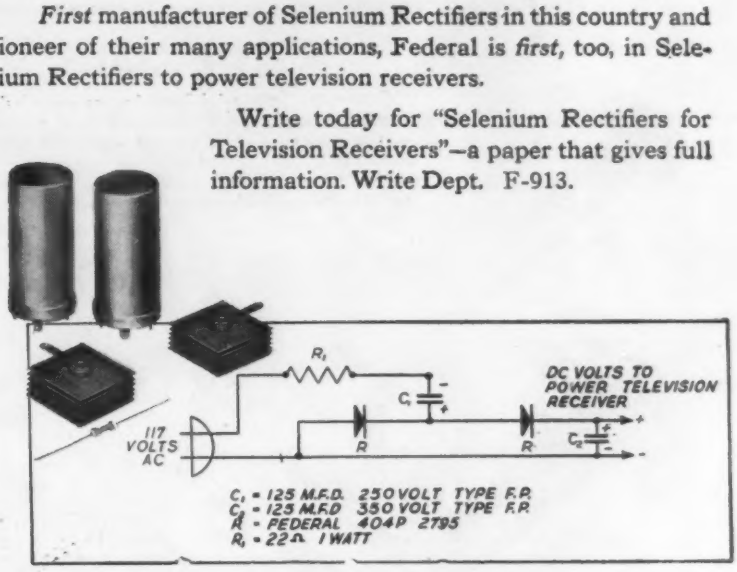

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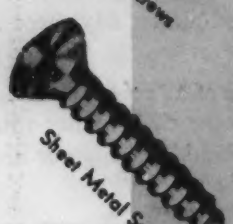

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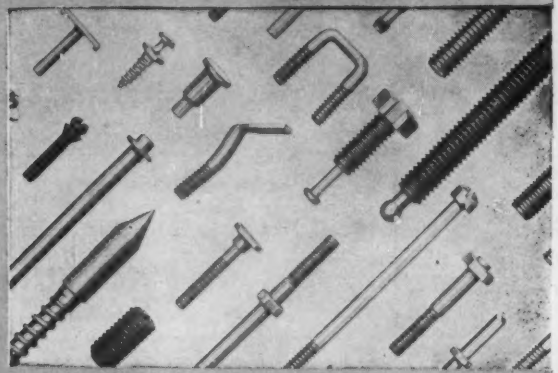

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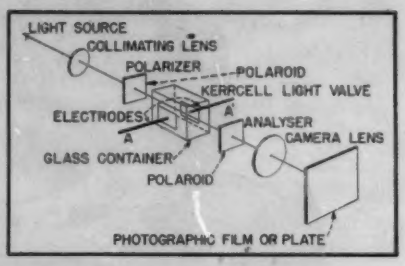

High speed Zarem shutter is Kerr cell between crossed polarizing filters

from the source is polarized in one direction by the first filter and, after passing through the cell, is blocked by the second filter. However when about 5,000 volts are applied across the electrodes of the cell the fluid with which it is filled rotates the light as it passes through so that the beam is unaffected by the second filter. The speed of exposure is controlled by the voltage pulses applied to the cell. A material that rotates the plane of polarization of light is said to be birefringent; application of the voltage makes the fluid become birefringent. The shutter can be operated at a frame rate of some 10,000,000 exposures per second.

Dynamic Sound Reproduction

BY T. S. KORN

Chercheur-libre
(Research Associate)
University of Brussels
Brussels, Belgium

AMPLIFIERS for sound reproduction usually have controls for volume and tone, but not for the dynamic range, or simply the dynamics. In fact little attention is given to the ratio of the loudest to the softest levels at which music is reproduced. A qualitative survey of the dynamic requirements of reproduction has been made. A simple circuit for controlling the dynamics has been developed to fill these requirements.

Dynamics of Music

When a volume expander is incorporated in a phonograph playback or radio receiver amplifier to restore the original dynamic range, compressed for recording or transmitting, the opinion of listeners about the enhanced musical contrast is not always favorable. The

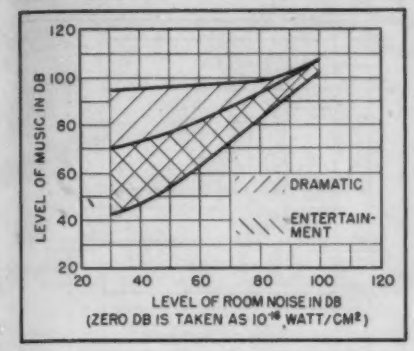

FIG. 1—Preferable dynamic range depends on the ambient noise level in the room

dynamics of music is originally suggested by the composer. The conductor may modify the dynamics in the light of his interpretation, behavior of listeners and local noise. However, the dynamics of music that is broadcast or recorded may not be appropriate for the conditions in the rooms in which it is reproduced. Hence some means of adjusting the dynamics to meet the prevailing auditory conditions is advisable.

The dynamics of music are limited on one hand by room noise and on the other by the highest admissible level for the listeners' ears. Both factors depend principally on the purpose the music is to serve. From the viewpoint of dynamics, musical programs can be classified for their dramatic or their entertainment value. Music reproduced for these two purposes requires different dynamic ranges as well as different average volume levels.

Audience Reaction

High fidelity reproducing systems should be designed to reproduce the full dynamic range of the program. However, listeners demand two types of reproduction, as indicated above: dramatic reproduction in which the listeners' attentions are concentrated on the program, and entertainment reproduction in which the program is an unobstrusive background to other interests. In dramatic reproduction, room noise is usually low (30 to 40 db) and a high level of forte (90 to 95 db) is acceptable, giving a dynamic range of from 40 to 50 db. On the other hand, entertainment reproduction is usually required in noisy rooms (60 to 90

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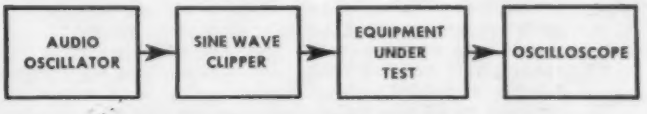
The B&W Sine Wave Clipper speeds accurate analysis of audio circuits, simplifies selection of components, and saves valuable time. It is a high quality laboratory instrument that will do most of the jobs usually assigned to a square wave generator costing about 10 times as much! Designed to be driven by an audio oscillator, the unit provides a clipped sine wave particularly useful in examining the transient and frequency response of audio circuits. Used in engineering work, repair work, or with equipment under development, it will quickly pay for itself many times over.



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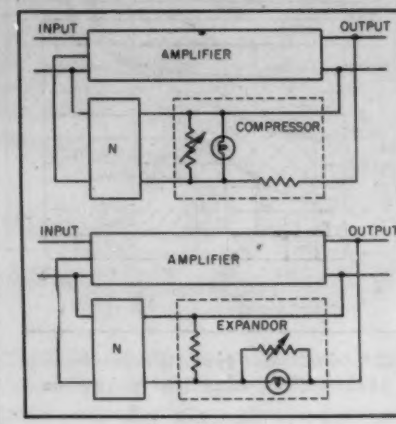

FIG. 2—Variable resistance controls the dynamic change that the lamp can produce

db). The music should not drop below the ambient noise nor rise dominantly above it; the dynamic range for public acceptance has to be below 25 db, possibly as low as 10 db. These ranges should be compared to the dynamic range of 20 to 25 db with which programs are usually transmitted or recorded. Figure 1 shows the dependence on the dynamic range of reproduction on the ambient noise.

Because of these wide dynamic ranges encountered in various conditions, it is advisable to incorporate a dynamic control in quality amplifiers.

Dynamic Control Circuit

Rather than use some form of the conventional dynamic control that requires additional tubes in the amplifier (and must be introduced outside the negative feedback loop usually used in high quality amplifiers) and that has long time constants, one can obtain dynamic control by varying the amount of feedback. Figure 2 shows circuits using this principle for either compression or expansion. The amount of feedback is varied by the nonlinear characteristic of an incandescent lamp, shown in Fig. 3.

In the circuit of Fig. 2 the feedback voltage is obtained from the secondary of the output transformer and is applied to the high-impedance control circuit. This circuit consists of a fixed resistsistance in parallel. A second linear network may be used to further adjust the amount of feedback. The

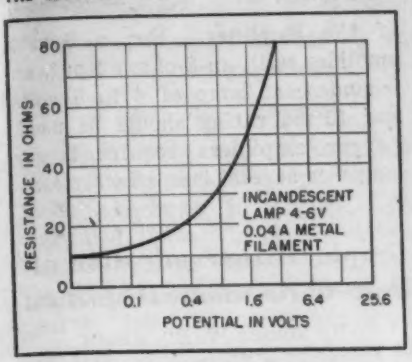

FIG. 3—At higher resistance than shown here resistance exponent is constant

control circuit, by changing the feedback in accordance with the signal level, produces the dynamic compression or expansion.

In this circuit the resistance of the incandescent lamp varies by a ratio of 10:1, thus, with appropriate values for the other circuit parameters, a volume compression or expansion of about 10 db can be obtained. The amount of dynamic change is directly controllable by the variable resistance. A tapped resistance and switch can be used to provide a sequence of dynamic steps from full compression to full expansion. The response of a dynamically controlled amplifier is shown in Fig. 4.

The time delay of the control circuit is determined by the thermal inertia of the filament of the incandescent lamp. By using a lamp rated at 40 ma or so the attack time is about 30 millisec (an attack time less than about 50 millisec is normally unnoticeable) and the release time is about 150 millisec (compared to 100 to 200 millisec of vacuum tube dynamic controls). The control circuit should be adjusted at the highest power output

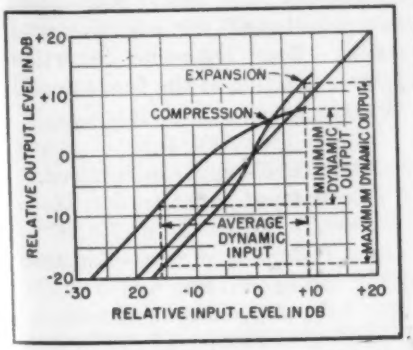

FIG. 4—Dynamic ranges obtainable from amplifier incorporating adjustable adc

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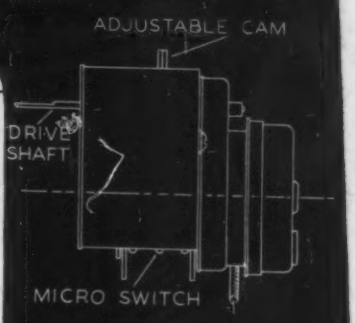

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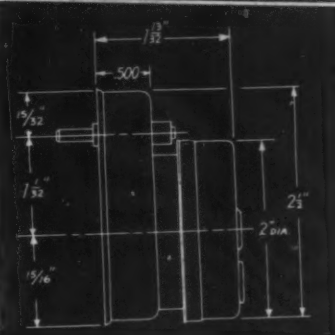

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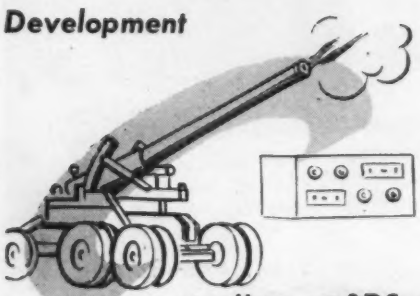

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of the amplifier. For a 5-watt amplifier with an 8-ohm output, an incandescent lamp of 4 to 6 volts and 40 ma rating should be used. Larger amplifiers require larger lamps or several lamps in series.

Graphical Determination of Percent Harmonic Distortion

By ROBERT W. BUCHHEIM
Instructor in Electrical Engineering
Yale University
New Haven, Conn.

IN DESIGNING resistance loaded amplifiers or analyzing vacuum tubes the relation between load resistance and harmonic distortion is frequently needed. Usually numerical calculations based on values read from characteristic curves are made to find this relation; however a graphical method can be used that is simpler. Furthermore, this graphical method has the advantage that it uses the distances from the characteristic curve directly without the necessity of converting them to numbers, and it has an accuracy that is more compatible with the original data than is the arithmetical computation.

Basis for the Method

The commonly used expressions for harmonic distortion are

$$D_2 = \frac{(I_H + I_L) - (I_X + I_Y)}{(I_H - I_L) + (I_X - I_Y)} \qquad (1)$$

$$D_3 = \frac{(I_H - I_L - 2(I_X - I_Y)}{2(I_H - I_L) + (I_X - I_Y)} \qquad (2)$$

where D_2 is the ratio of the second harmonic to the fundamental and D_3 is the ratio of the third harmonic to the fundamental currents; I_H is the plate current at the positive peak of the grid swing, I_L is the plate current at the negative peak, I_X is the plate current when the grid signal voltage is at half its positive peak, and I_Y is the plate current at half the negative grid swing. Total harmonic distortion D_0 as a fraction of the fundamental is given by

$$D_0 = (D_2^2 + D_3^2)^{1/2} \qquad (3)$$

A plot of D_0 vs R_L is required.

For ease of notation let: $A = (I_H + I_L)$, $B = (I_X + I_Y)$, $C = (I_H - I_L)$ and $D = (I_X - I_Y)$, then Eq. 3 can be written

$$D_0 = \frac{\{[2(A - B)]^2 + [C - 2D]^2\}^{1/2}}{2(C + D)} \qquad (4)$$

$$= N_0/2(C + D)$$

where $N_0^2 = [2(A - B)]^2 + [C - 2D]^2$

The quantities N_o and $(C + D)$ can be obtained graphically.

Illustrative Example

Consider a family of plate characteristics for a 6F6G power pentode as shown in Fig. 1. The operating point is chosen at the intersection of the E_B = 250-volt coordinate and the E_G = — 15-volt curve. Load lines corresponding to several likely load resistances are drawn through this operating point.

A sheet of coordinate paper is arranged as in the rest of Fig. 1

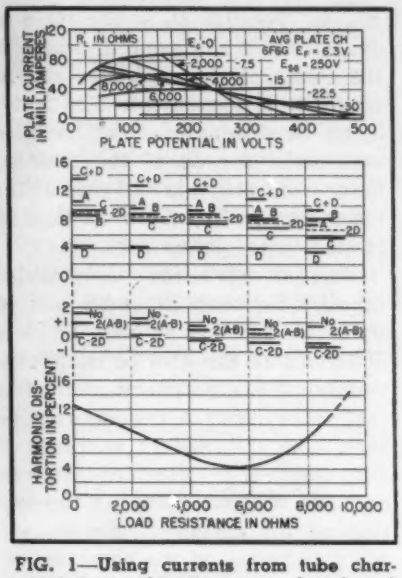

FIG. 1—Using currents from tube characteristic, combinations are plotted and differences and quadratic sumes obtained giving quantities from which percent harmonic distortion is obtained

with vertical lines labeled with the various values of load resistance to be considered. The ordinate of the top coordinate section is in milliamperes; its scale can be arbitrary or it can be transferred directly from above with dividers. Distances representing I_H, I_L, I_X, and I_T are transfered in this way so that a plot of these quantities vs R_L is obtained. There is no need to draw a careful curve through these values, but a free-hand curve helps in identifying them.

From these intermediate curves, curves of A, B, C and D can be obtained by graphical addition and subtraction in accordance with their definitions. Next, in a similar manner, curves of $2D$, $(C - 2D)$, $(C + D)$, $(A - B)$ and $2\ (A - B)$ are constructed.

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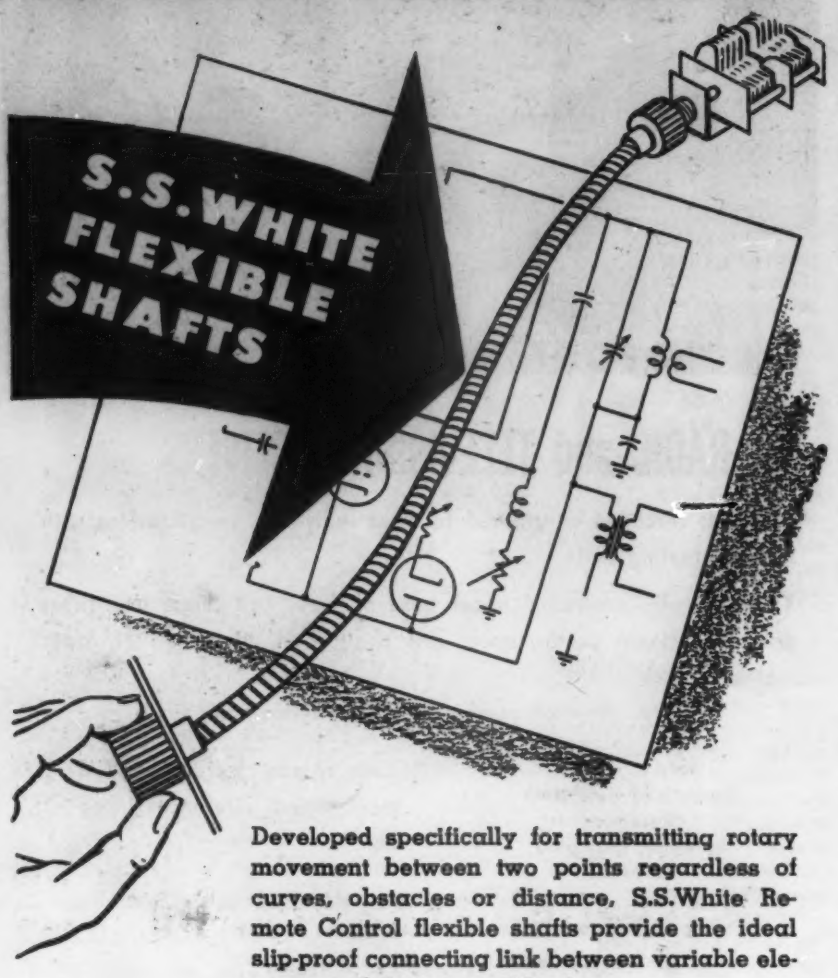

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tion of 2 $(A - .B)$ and $(C - 2D)$ is made by measuring these quantities at right angles to each other; the diagonal joining their ends is N_o. As shown in the diagram, the graph becomes crowded when the currents have been added to give their sums and differences. Hence the constructions are transferred, as made, to a clear section of the graph below. The distance of N_o is also plotted in this section.

When N_o and $2(C + D)$ have been obtained D_o is determined from slide rule manipulation using Eq. 4. Because D_o is the ratio of quantities of the same dimensions, the scales of the ordinates can be whatever is convenient. The factor 2 can be eliminated from the final expression for D_o if the scale of lower work graph is half that of the top section; $(C + D)$ must then be plotted in the lower part.

This construction is carried through for each R_L and a plot of D_o vs R_L made as in Fig. 1; plots of D_2 and D_3 can also be made conviently. This graphical method is fast and direct. A regular routine should be followed in carrying it out; many of the combinations can be made without changing the setting of the dividers. Errors are easily detected as the construction progresses by any radical singularities in the intermediate curves.

Oil Impregnated Capacitors

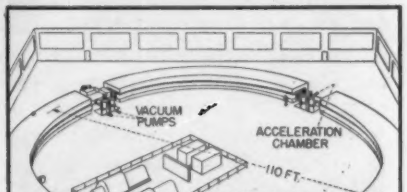
EXPERTS in the field have pointed out to us that characteristics of a few oil capacitors, published in these columns in May 1948, tell only part of the complicated (and apparently controversial) story. The ordinate axis of Fig. 1 should have been "Insulation in Megohm-Microfarads" and that of Fig. 4, "Percent of Capacitance at 25 C"; the author is sales representative for Sprague Electric Co. We hope to present more engineering data on this subject as it is made available.

SURVEY OF NEW TECHNIQUES

MAGNETIC FLUID CLUTCH, invented by Jacob Rabinow of the National

Bureau of Standards, provides smooth control and 100 percent efficiency (no slippage) at loads for which it has been designed. The clutch plates are operated in an oil bath in which finely powdered iron is suspended. Application of a magnetic field via an electromagnet aligns the iron powder from plate to plate producing a strong bond. Unlike conventional dry clutches, this clutch is free from chatter because the static and sliding frictions are practically the same. Its chief application appears to be in servomechanisms where its complete control through the electromagnet and complete locking are of great importance.

CYCLOTRON, to be built at University of California, will have four high-frequency acceleration chambers spaced between segments of the electromagnet. With 5,000 volts applied to each chamber, accelerated particle, injected by Van de Graaf generator, will be ejected toward Wilson cloud chamber after making a million trips around



Layout of projected cyclotron

cyclotron with an energy of 6,000 mev. Accelerator will require five years and $9 million for construction; magnet will weigh 10,000 tons and operate from a 5,000-kw source; machine will be pulsed, operating for about two seconds, then turned off for a few minutes. Experiments under direction of William Brobeck and Dr. E. O. Lawrence, director of the laboratory, have shown the design to be practical.

BACK in the 1890's, physicists argued heatedly over whether it should be "corpuscle" or "electron" for the smallest particle of negative electricity.

With This

Lear

High Fidelity
Variable Reluctance

MP-103
List Price
$12.00

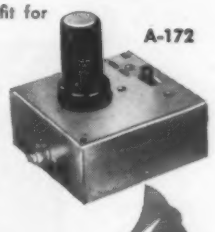
Magnetic Phono Pick-up

"Knee-Action" Steps Over Surface Noise

PICK-UP PROFIT FOR SERVICEMEN . . . Daily service calls turn into profitable sales with this new LEAR magnetic phonograph pick-up. Profit for you and new improved revolutionary record reproduction for your customers. Its flawless performance has set a new standard for pick-up quality . . . actually transforms old style record reproduction into full rich mellow tones.

In this variable reluctance pick-up, LEAR engineering has developed the "knee action" permanent sapphire stylus which assures minimum surface noise and full tonal beauty of sound on all installations.

Turn this fast selling LEAR magnetic phonograph pick-up into profit for you. Don't wait! Write today for complete discount price list.



A-172

To Complete Your LEAR Sound Installation
LEAR PRE-AMPLIFIER, List Price — $9.90

The new improved LEAR pre-amplifier provides additional amplification when used with MP-103 LEAR magnetic pick-up. Can be connected directly to old crystal cartridge input. Leads of convenient length are provided for connection into existing equipment. Two position switch permits high fidelity response to recordings.

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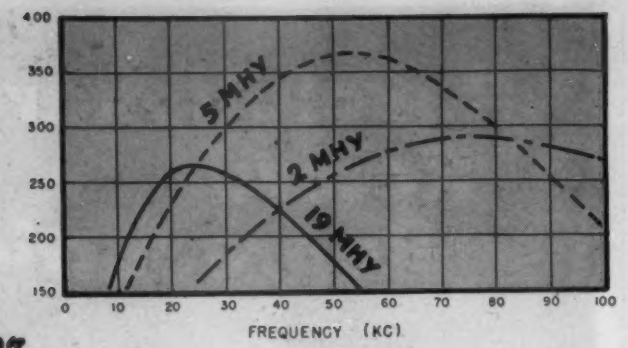

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SAN CARLOS, CALIFORNIA

LENKURT KNOWS HOW

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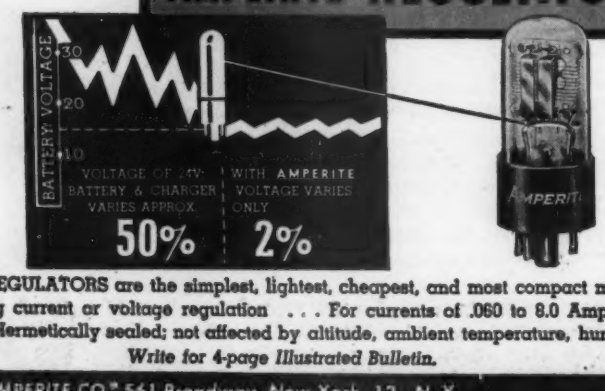
THERMOSTATIC METAL TYPE DELAY RELAYS

PROVIDE DELAYS RANGING FROM 1 TO 120 SECONDS

FEATURES:—Compensated for ambient temperature changes from —40° to 110° F . . . Hermetically sealed; not affected by altitude, moisture or other climate changes . . . Explosion-proof . . . Octal radio base . . . Compact, light, rugged, inexpensive . . . Circuits available: SPST Normally Open; SPST Normally Closed.

PROBLEM? *Send for "Special Problem Sheet" and Bulletin.*

AMPERITE REGULATORS



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Write for 4-page Illustrated Bulletin.

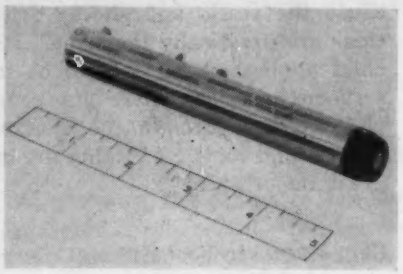
AMPERITE CO., 561 Broadway, New York 12, N. Y.
In Canada: Atlas Radio Corp., Ltd., 560 King St., W., Toronto

(continued from p 134)

mately 30 pounds assembled, and price is $119 without wire.

Miniature Capacitor

ENGINEERING RESEARCH ASSOCIATES, INC., 1902 W. Minnehaha Ave., St. Paul, Minn., has announced a new miniature variable capacitor having a self-contained



dial with micrometer. Rated capacitance is 9 to 585 μμf per section with less than 0.002 dissipation factor at radio frequencies.

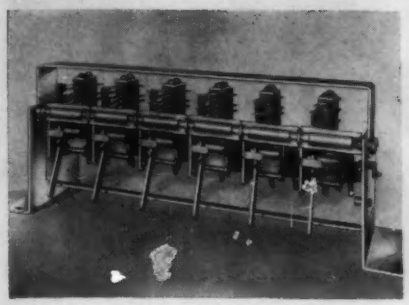
Recorder-Reproducer

FREDERICK HART & CO., INC., Poughkeepsie, N. Y. Model 60 sound-on-film recorder-reproducer is an all-purpose, lightweight unit which uses 35-mm film to produce a per-

manent sound record. A voice-actuated mechanism automatically starts and stops the machine at any voice level. Foot switch, earphones and other accessories are available for every application.

Indicator Relays

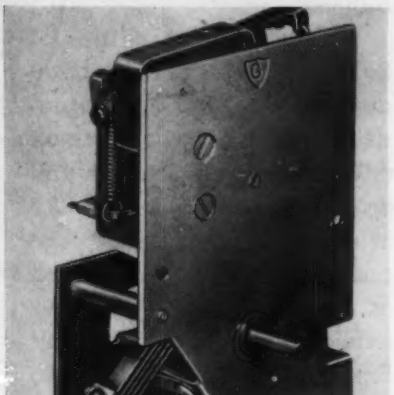
GUARDIAN ELECTRIC MFG. CO., 1625 W. Walnut St., Chicago 12, Ill. This bank of T-11 relays is designed for indicator circuits where numbers and animation such as lights, sound, or both, are in sequence. The



bar which resets the relay arm may be actuated manually, mechanically or electrically with a solenoid. Additional information can be obtained by writing to Dept. T-11.

Counting Device

GUARDIAN ELECTRIC MFG. CO., 1625 W. Walnut St., Chicago 12, Ill. This magnet-driven counter was primarily designed for registering the number of musical record selections received from remote points in a



centrally wired music station. The unit features a Series 15 magnet, standard counter, wire-arm counter actuating assembly, with a midget contact assembly having single-pole double-throw and single-pole single-throw switch combinations.

Liquid Level Control

GUARDIAN ELECTRIC MFG. CO., Dept. LL, 1625 W. Walnut St., Chicago 12, Ill. Series G-53143 liquid level control is used principally in carbonated beverage vendors to maintain the level of water in refrigerated storage tanks. The unit operates by means of long and short electrodes inserted through the top of the tank, and relays which start and

that keeps in step with Progress

THE problem of meeting new power and frequency requirements in communications systems, with minimum obsolescence, is solved by the Telepak line of transmitting equipment, the latest achievement in this field by Radio Receptor.

Telepak consists of a basic frame supporting a series of separately and easily removable units or cells of standard construction, varying in height according to power requirements. These unit assemblies are housed in standard cabinets, as illustrated.

Any cell may be easily removed to permit servicing or replacement by a new unit of different function or frequency. This adaptability offers another advantage as it permits the combination of units of all ratings in a single installation. Units are available in power output ratings varying from 500 watts to 3 kilowatts.

Remote control elements are also on the unit cell basis, and are capable of expansion along with other elements in the system.

It will pay you to look into the many exclusive features of Telepak, Radio Receptor's new transmitting system that enables you to keep in step with Progress.

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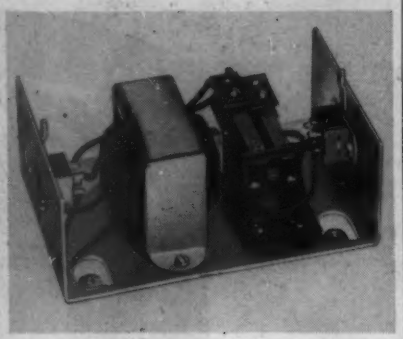
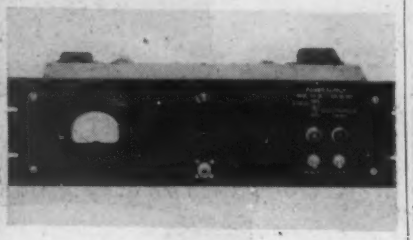


stop the pump motor. A transformer raises the voltage to 200 to reduce current required by the relay and to isolate the electrode circuits from the power line.

D-C Power Supply

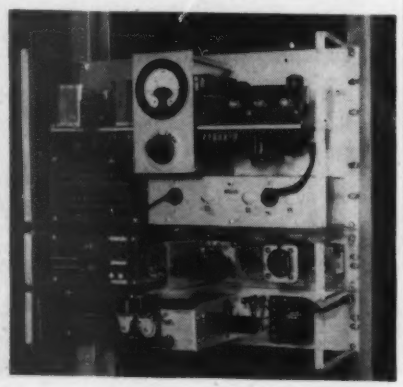
ROWE ENGINEERING CORP., 2422 North Pulaski Road, Chicago 39, Ill. Type IPS10000 10-kv Iso-volt



d-c power supply provides a source of continuously variable d-c voltage from 1,000 to 10,000 volts at current drains up to 5 milliamperes. It features a regulation of 0.1 percent with a 0.05-percent ripple. Power drain is approximately 350 watts at full load.

Pilot Regulator

LENKURT ELECTRIC CO., 1108 County Road, San Carlos, Calif. An all-electronic telephone pilot regulator has been designed for use with 3-channel carrier systems and other possible applications as well. It occupies 10½ inches of rack space,



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combining automatic level control with automatic slope equalization. Corrections are made to 2 db or less in 20-db variation. Weight is 40 lb.

Radiation Detector

TECHNICAL ASSOCIATES, 3730 San Fernando Road, Glendale 4, Calif. Model F-3 portable radiation detector has two sensitivity ranges:

low, 0.5 milliroentgen per minute; high, 0.017 per minute. As supplied, the instrument includes a Geiger counter tube, probe, headphones, batteries, and manual of operation.

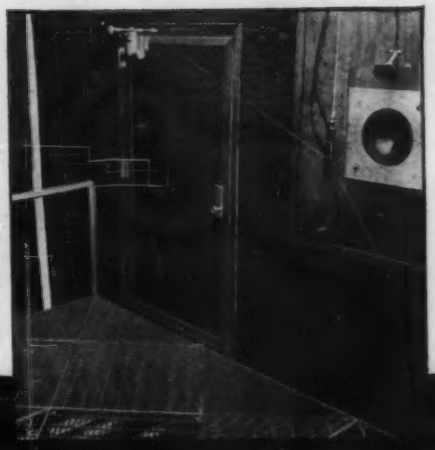
Magnetic Cartridge

WEBSTER ELECTRIC CO., Racine, Wisconsin. The Featheride, a mag-

netic cartridge with osmium-tipped needle, exerts a tracking pressure of one ounce, giving 0.1 volt output at 1,000 cps. The unit weighs 25 grams.

Telephone Amplifier

INTERCONTINENTAL INVENTIONS MANAGEMENT CORP., 60 E. 42nd St., New York, N. Y. The Simplophone, a small desk telephone amplifier, is designed to provide two-way con-



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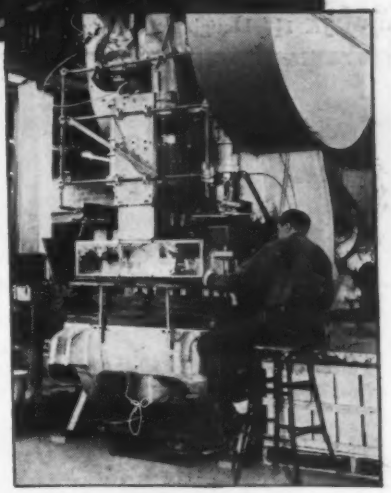
Speaker production lines turning out speakers with "the aluminum foil base voice coil."



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NEW, greater facilities at Electronics Park mean speakers in greater supply to meet your requirements. Straight-line production plus tremendous capacity provide manufacturers with a completely dependable source for speakers of all sizes.

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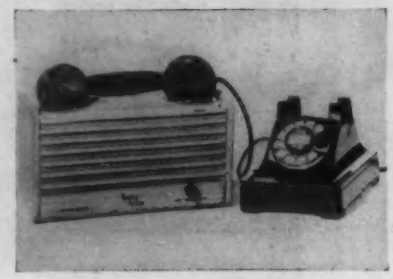
JK CRYSTALS

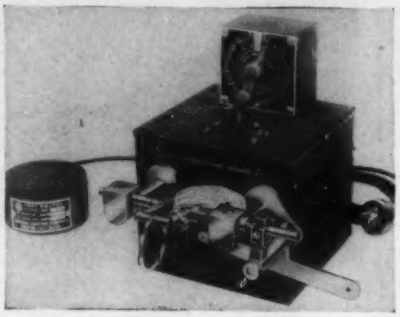
NEW PRODUCTS (continued)



versation leaving the caller's hands free to perform other tasks; also to provide group listening facilities. It is useful in busy offices and where telephone waiting time is a factor. Retail net is $39.95.

Soldering Machine

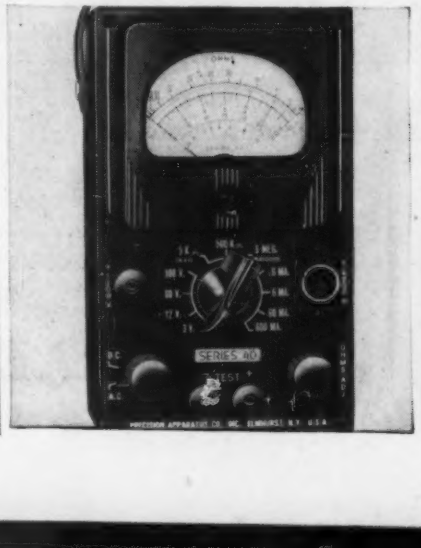
JOYAL PRODUCTS, INC., 12 Grafton Ave., Newark, N. J. A newly developed production soldering machine which operates like a foot

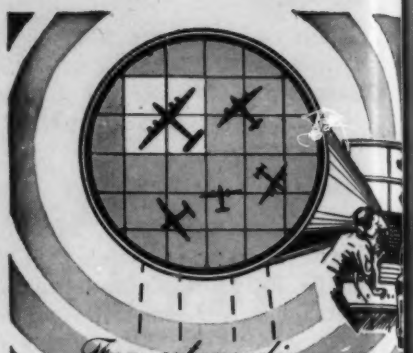


press was designed for the jewelry field and for manufacturers of instruments and small products. The machine is portable and operates on 110-volt a-c.

Wide-Range Tester

PRECISION APPARATUS CO., INC., 92-27 Horace Harding Blvd., Elmhurst, N. Y., has announced the Series 40 circuit tester with dimensions of 3¾ × 6¼ × 2½ inches. The





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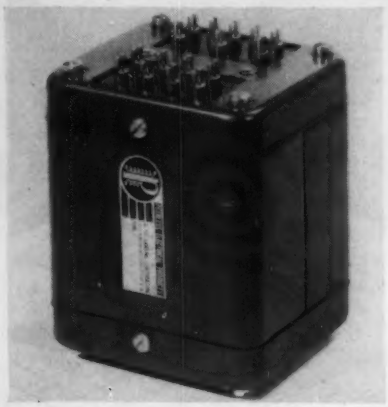
unit affords 31 a-c and d-c ranges to 6,000 volts, 600 ma, + 70 db and 5 megohms. Two pin jacks serve all standard functions and a special recessed safety jack provides for the 6,000 volt circuit.

Audio Transformers

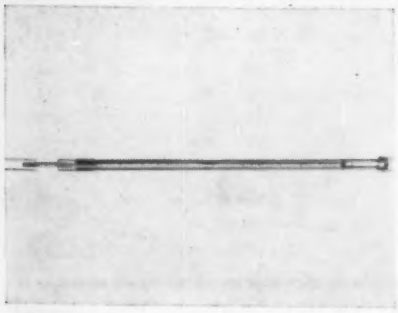
ALTEC LANSING CORP., Peerless Electrical Products Division, 6920 McKinley Ave., Los Angeles 1,



Calif., announces a new 20-20 line of audio transformers, flat within 1 db from 20 cycles to 20,000 cycles.

Signal Measurement

DECIMETER, INC., 1428 Market St., Denver, Colorado. The DM103W slipstick wavemeter was designed for quick and accurate frequency readings on oscillators, receivers or



transmitters in the uhf spectrum. Accuracy is 2 percent or better and range is 90 to 3,000 mc. Further information is given in circular 11F.

Cavity Meters

SPERRY GYROSCOPE CO., Great Neck, New York, announces a line of high-Q tunable cavities for measuring microwave frequencies where great accuracy is required. The resonant cavities are electroformed

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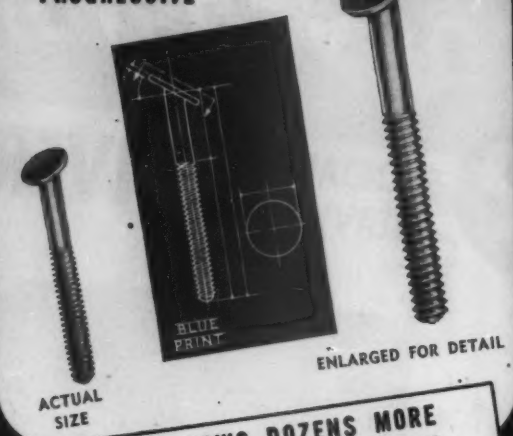

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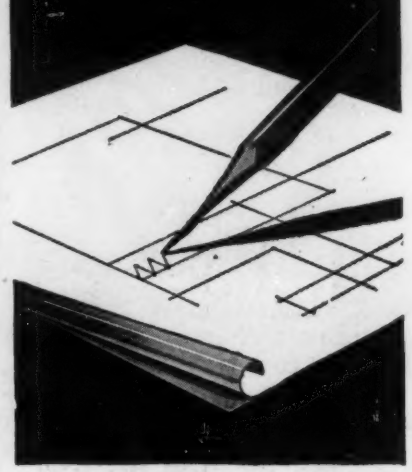

●Imperial Pencil Tracing Cloth has the same superbly uniform cloth foundation and transparency as the world famous Imperial Tracing Cloth. But it is distinguished by its special dull drawing surface, on which hard pencils can be used, giving clean, sharp, opaque, non-smudging lines.

Erasures are made easily, without damage. It gives sharp, contrasting prints of the finest lines. It resists the effects of time and wear, and does not become brittle or opaque.

Imperial Pencil Tracing Cloth is right for ink drawings as well.

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Designers and Manufacturers of Broadcast Speech Equipment, School Sound Systems and Recording Equipment.

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Bardwell & McAlister's new line of Commercial Amplifiers answers the great demand of sound engineers for commercial amplifiers embodying the principles used in "custom-built" units which have been successful in the sound equipment of the motion picture industry. These principles result in high fidelity reproduction at any setting of volume controls up to full rated output with less than 4% distortion, versatility of application, ease of operation and the longer life found only in Bardwell & McAlister Studio Quality Amplification Systems. Manufactured by Union Craftsmen and fully licensed.

Write for our sound equipment catalog and technical bulletins. Dealer inquiries invited.

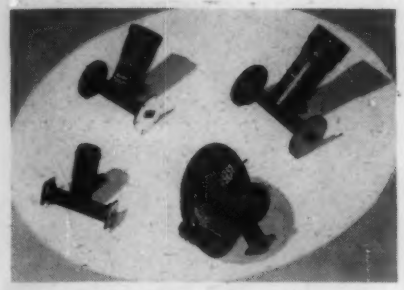
13

A BM PRODUCT

ELECTRONIC DIVISION

BARDWELL & McALISTER, INC.

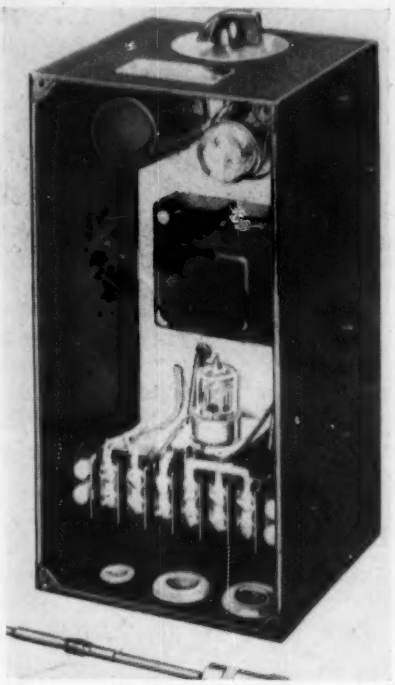
BOX 1310, HOLLYWOOD 28, CALIFORNIA



to obtain minute tolerances, stress-free metal and a true circular shape. The instruments provide continuous frequency coverage from 2,575 to 3,750 and 4,500 to 10,500 mc.

Temperature Control

THOMAS A. EDISON, INC., West Orange, N. J., has developed a temperature control which uses a single electronic tube with an electrical resistance-type bulb for thermal

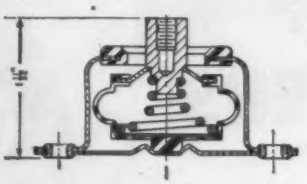


pickup and is of the on-off type. Units are available to cover the temperature range from −100 F to 1,200 F and are adjustable within a range of several hundred degrees.

Burglar Alarm

RIPLEY CO., INC., Middletown, Conn. Using a modulated, invisible light beam, the new burglar alarm is proof against attempt at breakthrough by shining a flashlight into the phototube. The receiver portion is tuned to the modulated frequency of the transmitter, so that

Type 770 Vibration Isolator



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We offer a complete line of highly engineered Vibration and Impact Isolators for commercial, industrial, and military applications . . . also an Engineering consulting service on special problems.

A letter from you will give us the opportunity to demonstrate how we can help you.

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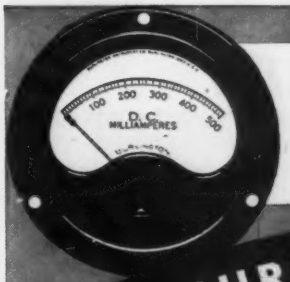
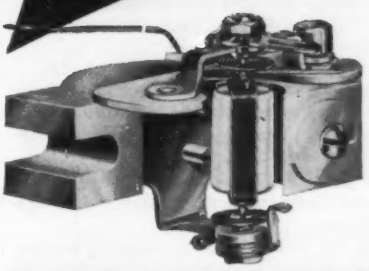


CERAMIC POINTER STOPS

WHY BURLINGTON PANEL INSTRUMENTS PROVIDE UTMOST RELIABILITY . . .



CERAMIC POINTER STOPS are used to prevent damage to the pointer due to accidental application of sudden overloads. All ranges AC and DC available in 2½", 3½", 4½" rectangular or round case styles and are fully guaranteed for one year against defects in workmanship or material. Refer inquiries to Dept. F78.

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WITH THE KNURLED CUP POINT

("The screw that won't shake loose")

This Knurled Cup Point "Unbrako" is a "Fastener" that positively won't shake loose.

A loose Fastener invariably causes shut-downs, loss of production and increased costs, all of which this "Unbrako" prevents.

This is how: That Knurled Cup Point digs-in, stays dug and holds tight, regardless of the most chattering vibration. Incidentally, the "Unbrako" Self-Locker can be used again and again. In sizes from #4 to 1½" diameter—full range of lengths.

"Unbrako" Screw Products can also be furnished in Brass, Stainless Steel, Monel, Bronze or whatever your requirements may be.

Ask for your copy of the "Unbrako" Catalog.

Ask us for the name and address of your nearest "Unbrako" Industrial Distributor.

Knurling of Socket Screws originated with "Unbrako" in 1934.

OVER 45 YEARS IN BUSINESS

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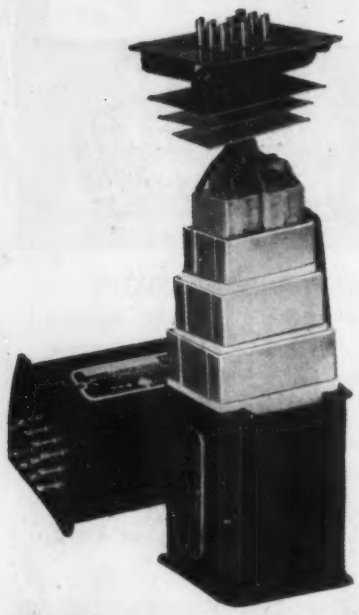
FOR LOW HUM.. HIGH FIDELITY

SPECIFY KENYON TELESCOPIC SHIELDED HUMBUCKING TRANSFORMERS



For low hum and high fidelity Kenyon telescoping shield transformers practically eliminate hum pick-up wherever high quality sound applications are required.

CHECK THESE ADVANTAGES

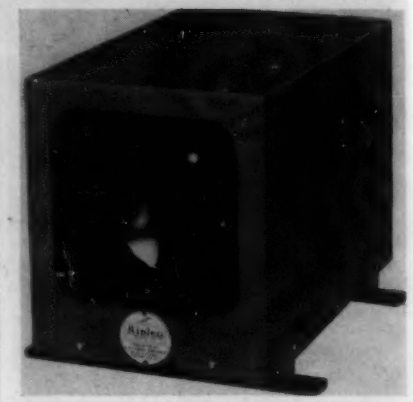
- LOW HUM PICK-UP . . . Assures high gain with minimum hum in high fidelity systems.
- HIGH FIDELITY . . . Frequency response flat within ± 1 db from 30 to 20,000 cycles.
- DIFFERENT HUM RATIOS . . . Degrees of hum reduction with P-200 series ranges from 50 db to 90 db below input level . . . made possible by unique humbuckling coil construction plus multiple high efficiency electromagnetic shields.
- QUALITY DESIGN . . . Electrostatic shielding between windings.
- WIDE INPUT IMPEDENCE MATCHING RANGE.
- EXCELLENT OVERALL PERFORMANCE . . . Rugged construction, lightweight - mounts on either end.
- SAVES TIME . . . In design . . . in trouble shooting . . . in production.

Our standard line will save you time and money. Send for our catalog for complete technical data on specific types.

For any iron cored component problems that are off the beaten track, consult with our engineering department. No obligation, of course.

KENYON TRANSFORMER CO., Inc.

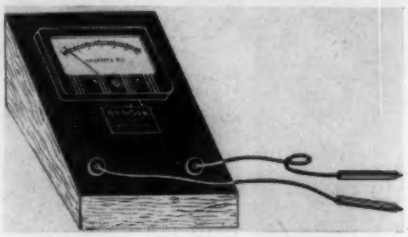
840 BARRY STREET NEW YORK, U. S. A.



any change in frequency or reduction of light intensity sounds the alarm. Lens mountings have micrometer adjustments to facilitate focusing on the phototube. The unit is weather-tight and rust-proof.

High-Voltage Meter

SPELLMAN TELEVISION CO., INC., 130 W. 24th St., New York 11, N. Y., announces a new high-voltage meter for television service men, laboratory technicians and ex-



perimenters. The meter, with range from 0 to 30 kv, draws only 20 microamperes. Technical information is available.

Indexing Turntable

SHERMAN INDUSTRIAL ELECTRONICS CO., 505 Washington Ave., Belleville 9, N. J., has developed an indexing turntable for induction soldering, brazing, or heat treating. Operation requires 60-pound

#1422

FOR HIGH TEMPERATURE HF AND UHF INSULATION

G-E #1422 rod stock was specified for these UG connector beads.

● Does your high-frequency or ultra-high-frequency insulating problem call for a material that is comparatively low in cost . . . easy to machine . . . resistant to high temperatures? Then investigate G-E #1422 . . . a new development in plastics!

You get all these qualities when you order G-E #1422 rod or plate stock. That's why this material is particularly well suited for use as structural components in HF or UHF equipment. Where a low power factor is required . . . where high operating temperatures prevent the use of commercially available materials such as polystyrene . . . use G-E #1422.

For more details, just write *Section AF-7, Chemical Department, General Electric Company, Pittsfield, Massachusetts.*

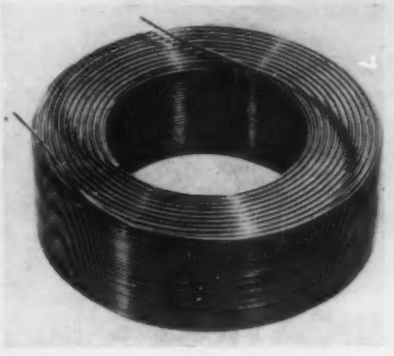
GENERAL ELECTRIC

CD48-H3

air supply and 220-volt, 60-cycle single-phase power. As many as 12 work stations can be provided on the standard turntable top.

Magnet Coil

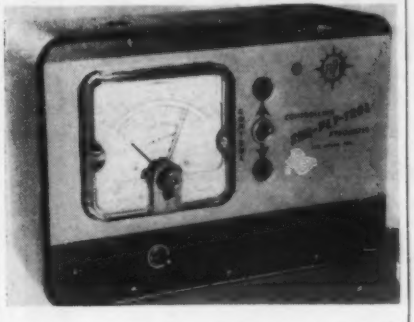
G. H. LELAND, INC., 118 Webster St., Dayton 2, Ohio. The Ledex extra-precision magnet coil is layer



wound by a new and exclusive method. Coils are concentric and symmetrical in shape. Further information is available on request.

Controlling Pyrometer

ASSEMBLY PRODUCTS INC., Main & Bell Sts., Chagrin Falls, Ohio. The Simplytrol indicating and controlling pyrometer is a thermocouple-type control for furnaces, ovens, kilns, etc. It operates on the micro-



contact principle, from 110 or 220 volts a-c or 110 volts d-c. The unit can be used for permanent installations or as a portable control for temporary setups.

Electrolytic Capacitors

CORNELL-DUBILIER ELECTRIC CORP., South Plainfield, N. J. Type AVL hermetically sealed electrolytic capacitors are recommended for use in marine or aircraft applications or wherever high humidity is encountered. Data sheet 110 gives information on various capacitances,

HARVEY has BEST BUYS

FM TRANSLATOR
General Electric Model XFM-1

Post-war version of the old G.E. J.F.M-90 Translator which was used and enjoyed by tens of thousands of discriminating radio listeners.

Covers 88-108 mc range, dial 12 inches long, uses guillotine tuning for highest efficiency, high stability. Designed for export, has power inputs for 110 to 250 volts, 50/60 cy. Used in conjunction with good audio section or separate amplifier will provide best FM listening you ever heard. In attractive natural walnut cabinet — 10¾" high x 15¾" wide x 11⅜" deep, complete with 8 tubes. Tropic-proof construction. Quantity limited, no more available. Get your order in while they last!

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Complete kit of parts, including all hardware, pre-wired and aligned RCA front end, condensers, resistors, punched chassis, all tubes including kine, complete manual with service notes, all RCA..... **$198.50**

NOTE: All prices are Net, F.O.B. N.Y.C. and are subject to change without notice.

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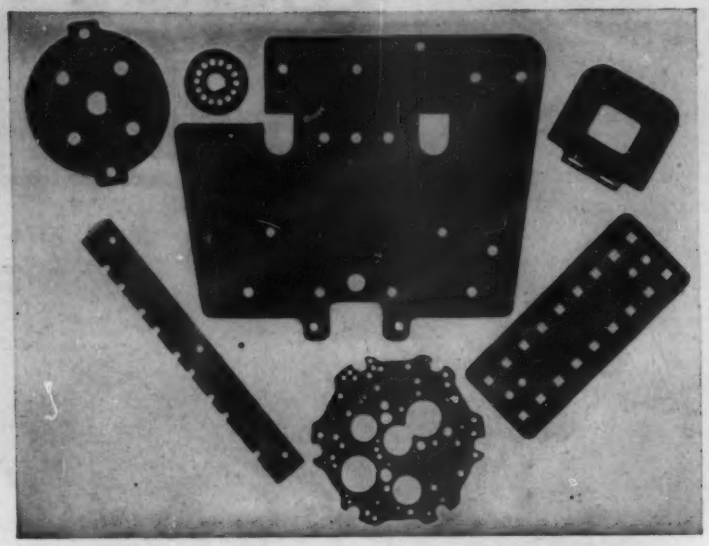

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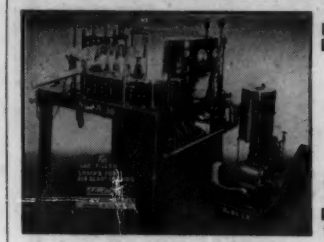

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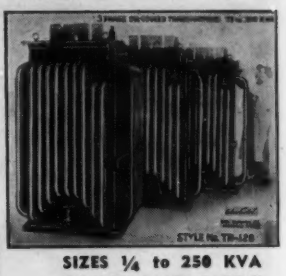

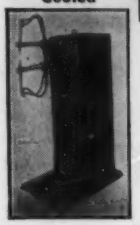

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FOR ALL PURPOSES
SIZES ¼ to 250 KVA

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TYPE P8
125 °C
Silicone
OIL CAPACITORS
SOLVES THE HIGH HEAT CONDENSER PROBLEM

- New silicone oil capacitors for continuous A/C-D/C up to 125° C.
- Made in ceramic or bakelized tubes.
- Cap. — .00005 to 1.0 M.F.D. From 100 volts to 20000 volts.

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Silicone News

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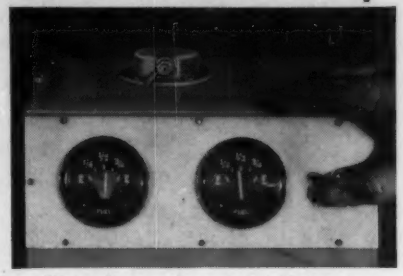
Silicones Mean Stability



Silicone damping of gauge at right eliminates familiar fluttering of pointer shown in untreated automobile instrument at left.

Design frequently involves a compromise between simplicity of construction and the properties of available materials. New materials are interesting because they generally enable engineers to find more simple and therefore more efficient solutions to design problems. Damping is one of the problems that has been complicated by a lack of stability in fluids.

The instrument division of a large automotive parts manufacturer was not satisfied with the use of inertia wheels, air vanes, or magnetic damping to eliminate the fluttering of instrument pointers. Liquid damping had been considered, but all ordinary light oils or greases thinned excessively when hot or thickened and became useless when cold. More than two years ago, however, their engineers started testing some of our high viscosity silicone fluids.

Extensive road testing has proved that a fraction of a drop of our silicone fluid on the bearings performs better and is more economical than any of the more complicated mechanical damping devices. In tests conducted by aircraft manufacturers where operating conditions for instruments are even more severe, silicone fluid damping was found to be the only entirely successful method. Test performance was so completely satisfactory that the instrument division is now using our DC 200 Silicone Fluid to damp electrical instruments, speedometers, tachometers and gauges.

Among other unique and useful properties are a high degree of stability, a relatively constant viscosity over a very wide temperature range, and good lubricity between certain metal combinations. Our fluids are available in viscosities ranging from 0.65 to more than 250,000 centistokes. For more information phone our nearest branch office or write for catalog No. N 1-16.

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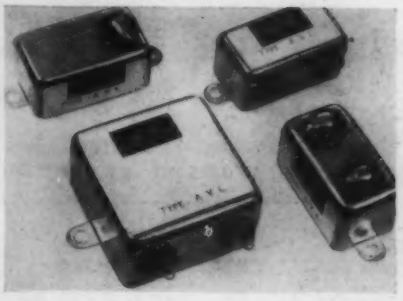
FIRST IN SILICONES



while No. 111 covers a capacitor with a rating of 24,000 μf at 6 working volts.

Phase-Modulated Mike

STEPHENS MFG. CORP., 10416 National Blvd., Los Angeles 34, Calif. Model C-1 microphone uses carrier-frequency phase modulation. The

pickup assembly is ovoid in shape and only 1 x 1¼ inches in size. Low response is linear to one-half cycle in 24 hours. The unit features a high signal-to-noise ratio.

Terminal Strip-Socket

YATES ENGINEERING SERVICES, Box 67M, Cranford, N. J., has developed a new combination tube socket-mounting strip for both point-to-

point and cabled wiring layouts. The unit will soon be available singly or in multiple gangs for such assemblies as audio units or midget radio chassis.

Rectifier Tube

NATIONAL ELECTRONICS, INC., Batavia Ave., Geneva, Ill. The NL-617 is a compact, 5-ampere industrial rectifier tube designed for heavy

MEASUREMENTS CORPORATION
Model 59

2.2 mc. to 400 mc.

MEGACYCLE METER

Radio's newest, multi-purpose instrument consisting of a grid-dip oscillator connected to its power supply by a flexible cord.

Check these applications:

- For determining the resonant frequency of tuned circuits, antennas, transmission lines, by-pass condensers, chokes, coils.
- For measuring capacitance, inductance, Q, mutual inductance.
- For preliminary tracking and alignment of receivers.
- As an auxiliary signal generator; modulated or unmodulated.
- For antenna tuning and transmitter neutralizing, power off.
- For locating parasitic circuits and spurious resonances.
- As a low sensitivity receiver for signal tracing.

MANUFACTURERS OF
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Pulse Generators
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Phase Sequence Indicators
Television and FM Test Equipment

SPECIFICATIONS:

Power Unit: 5⅛" wide; 6⅛" high; 7½" deep. Oscillator Unit: 3¾" diameter; 2" deep.

FREQUENCY:
2.2 mc. to 400 mc.; seven plug-in coils.

MODULATION:
CW or 120 cycles; or external.

POWER SUPPLY:
110-120 volts, 50-60 cycles; 20 watts.

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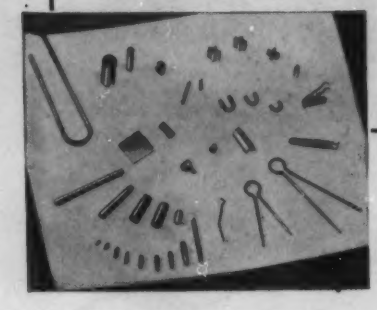
SLIP RINGS, RELAYS AND SWITCHES



Standard Ney precious metal alloys with accurately defined properties are now available for prompt delivery in commercial quantities, and our Research Laboratory is ideally equipped to develop and test other special alloys to meet your rigid specifications.

PALINEY #7

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PALINEY #7 is being used for a contact material on potentiometers wound with a nickel-chrome alloy resistance wire. This combination is consistently producing units with life of better than one million cycles and maintained accuracy of 0.1% or better throughout the life of the unit.

NEY-ORO #28

SLIP RING BRUSHES

NEY-ORO #28 is a special alloy developed as a contact brush material for uses against coin silver slip rings. Laboratory tests and reports from users indicate life of better than 10 million revolutions with no electrical noise.

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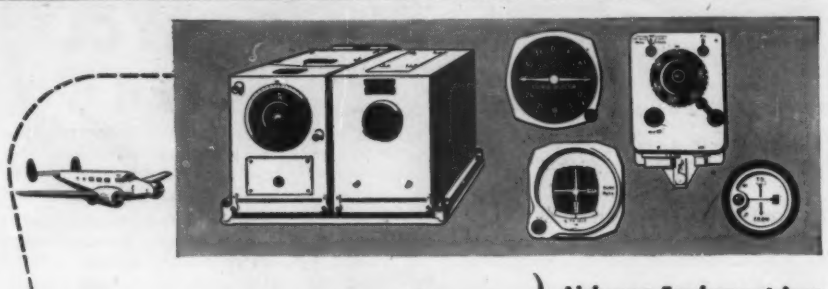

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Airborne Equipment for:

OMNI-DIRECTIONAL RANGES
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The Type 15A VHF Navigational Receiving Equipment (illustrated) provides for reception on the new Omni-Directional Ranges as well as operation on both types of VHF Runway Localizers, and the VHF Visual-Aural Airways Ranges. Simultaneous voice feature is included on these ranges. The *tunable* A.R.C. Receiver permits selection of any VHF aircraft frequency.

The A.R.C. Type 17 or A.R.C. Type 18 is the companion communication equipment normally associated with the Type 15A. The Type 17 VHF Communication Equipment adds independent two-way VHF communication facilities. The Type 18 adds VHF Transmitting Equipment only. All Type 17 and 18 units are type-certificated by the CAA.

The dependability and performance of these VHF Communication and Navigation Systems spells increased safety in flight. Specify A.R.C. for your next installation.

ARC **Aircraft Radio Corporation**

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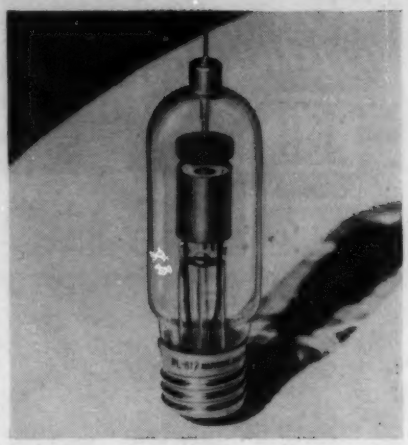
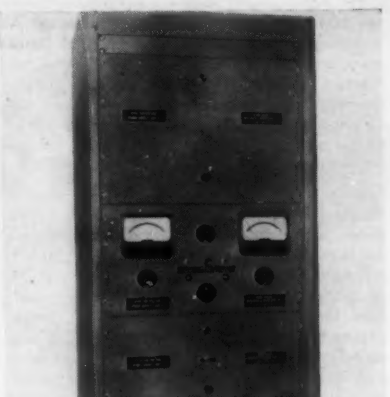
DEPENDABLE ELECTRONIC EQUIPMENT SINCE 1928



duty applications at voltages up to 600 volts d-c. Low condensed mercury temperature makes possible a peak inverse voltage rating of 1,000 volts.

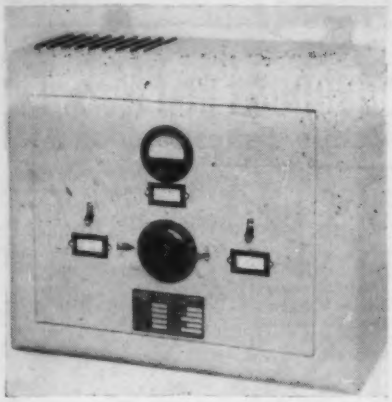
D-C Power Supply

FURST ELECTRONICS, 800 W. North Ave., Chicago 22, Ill. Model 710-SR d-c power supply features a stable basic regulator circuit. Output voltage is continuously adjustable over a range of less than 600 to more than 1,500 volts by the operation of a control knob on the front panel. The unit is built for low-current devices such as Geiger tubes.



Stabilized Rectifier

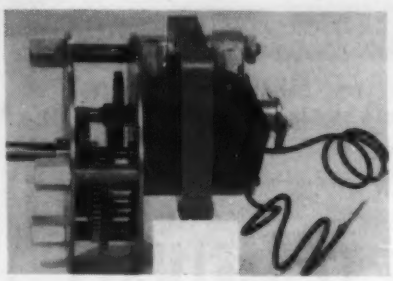
INDUSTRIAL ELECTRONICS AND TRANSFORMER CO., Dept. EE, 1801 East Slauson Ave., Los Angeles 11, Calif. The new stabilized rectifier was developed for installation wherever unattended battery charging is a necessity. Voltage regulating transformers compensate for variations in a-c line voltages to



selenium rectifiers. The output current is 4, 6, or 12 amperes, voltage from 3 to 60 cell ratings; and a-c input can be 110 or 220 volts.

Gear Train

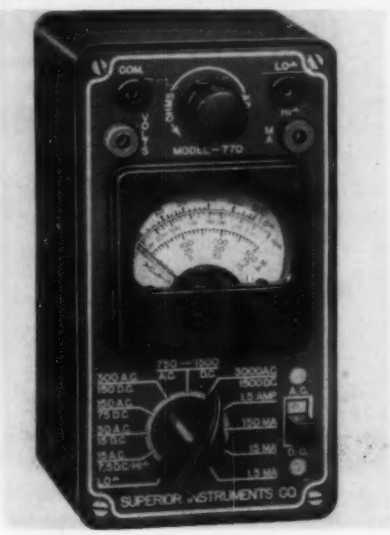
GLEASON-AVERY, INC., Auburn, N. Y. A new gear train for use with the B-30 series of small synchronous and nonsynchronous mo-



tors can be geared to produce clockwise or counterclockwise speeds from 400 to 1 rpm on the final shaft.

Pocket-Size Tester

SUPERIOR INSTRUMENTS CO., 227 Fulton St., New York 7, N. Y. Model



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From 10VA to 300 KVA Dry-Type Only, Both Open and Encased, 1, 2, & 3 Phase 15 to 400 Cycles.

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No Elements to Burn Out

Instant ON and OFF Action

Can't shock operator

Plastic Insulated
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COMPLETE with foot switch and low voltage transformer

SOLDER STAYS ON WORK. IT WILL NOT CLING TO THE ALUMINUM ALLOY PLIER JAWS

FLEXIBLE CORD

PLIERS ARE 6½" LONG

No current used until switch is closed

Here's how FAST they work—
Grip connection to be made... step on switch... apply solder... release switch.

A PRODUCT OF
DURST MANUFACTURING CO.
6671 SUNSET BOULEVARD, OFFICE 1585, LOS ANGELES 28, CALIF.

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PRECISION POTENTIOMETERS

Toroidal and Sinusoidal

For use in computing and analyzing devices; generation of low frequency saw tooth and sine waves; controls for radio and radar equipment; position indicators; servomechanisms; electro medical instruments, measuring devices—telemetering; gun fire control where 360° rotation, high precision and low noise levels are essential.

The type RL14MS sinusoidal potentiometer is illustrated. It is wound to a total resistance of 35,400 ohms and provides two voltages proportional to the sine and cosine of the shaft angle. It will generate a sine wave true within ±.6%. Overall dimensions are 4⅜" diameter x 4 11/32 long plus shaft extension ¼" diameter x 1¼" long.

Write for Bulletin F-68

THE GAMEWELL COMPANY

Newton Upper Falls 64, Massachusetts

GAMEWELL

PREMAX

Antennas For FM & TV

Insure Better Reception

Extended V-Type Dipole Antenna for all frequencies between 44 and 216 mc. Permits proper impedance matching to 300 ohm line for TV and FM.

Adjustable V Dipole Antenna for maximum response on FM and TV bands. Dipoles may be adjusted to angle best suited for clear reception and to counteract electrical noise or reflected signal. Ideal for use in congested areas.

Similar to preceding excepting it is equipped with reflector to permit better reception on distant stations. Ideal for all TV and FM installations.

Write for Catalog and Prices.

Premax Products

Div. Chisholm-Ryder Co., Inc.
4810 Highland Ave., Niagara Falls, N. Y.

PIPE COUPLINGS

ELECTRICALLY HEATED PRESSURE HEADS

CONTINUOUS FILM RECORDING CAMERAS

AND EQUIPMENT FOR CATHODE RAY

OSCILLOGRAPHY, ETC.

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TERMINALS

FOR

ELECTRIC WIRES

•

CONDENSER PLATES
SMALL METAL STAMPINGS

in accordance
with Customer's Prints

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ACCURACY • PRECISION
REASONABLE DIE CHARGES

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Modern Equipment and Factory
No Screw Machine Parts

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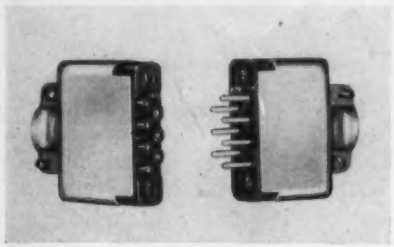
PATTON - MacGUYER COMPANY
17 VIRGINIA AVENUE
PROVIDENCE, R. I.

770 pocket-size volt-ohm-milliammeter was designed for radio and electrical appliance servicemen. Sensitivity is 1,000 ohms per volt. Its two resistance ranges are from 0 to 500 ohms and 0 to 1 megohm.

Seven Contact Connector

WINCHESTER ELECTRONICS Co., 6 E. 46th St., New York 17, N. Y. The seven-contact lightweight, aircraft-type connector has a breakdown voltage between contacts of 7,500



volts d-c and 5,300 volts a-c. Melamine molded parts with telescoping barriers provide long creepage paths. Weight of the connector is 0.8 ounce.

Volt-Ohm-Milliammeter

THE TRIPLETT ELECTRICAL INSTRUMENT Co., Bluffton, Ohio. Model 2451 electronic volt-ohm-milliammeter was designed for simple oper-

ation, broad test facilities and speed. It eliminates switching back and forth from one range to another to balance the circuit, and requires only zeroing the meter on the range to be used.

Pulse Generator

KAY ELECTRIC Co., Pine Brook, N. J., announces the Mega-Pulser, an ultra-short pulse generator, providing a pulse with a spectrum

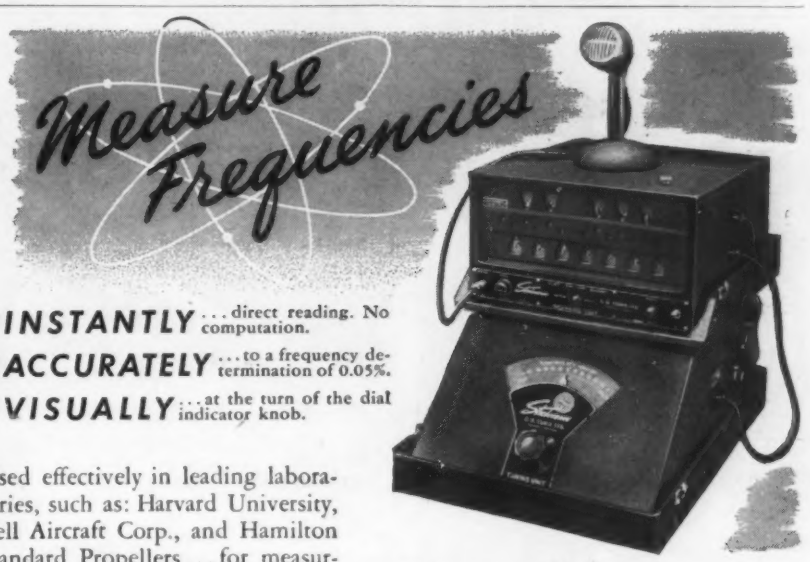
High speed machine-winding of electric motor armatures necessarily exposes magnet wire to some rugged treatment.

The all-around (in the groove and out) "windability" of ESSEX EXTRA TEST MAGNET WIRE in this and other exacting applications cannot be excelled.

ESSEX WIRE CORP.
FORT WAYNE 6, INDIANA

WIRE SX PRODUCTS

Plants: Fort Wayne, Indiana; Detroit, Michigan; Anaheim, California. Warehouses* and Sales Offices: *Atlanta, Ga.; *Boston, Mass.; *Chicago, Ill.; Dallas, Texas; Dayton, Ohio; *Detroit, Mich.; Kansas City, Mo.; *Newark, N.J.; Philadelphia, Pa.; *St. Louis, Mo.; Cleveland, Ohio; Milwaukee, Wis.; San Francisco, Calif.; *Los Angeles, Calif.



- **INSTANTLY** ... direct reading. No computation.
- **ACCURATELY** ... to a frequency determination of 0.05%.
- **VISUALLY** ... at the turn of the dial indicator knob.

Used effectively in leading laboratories, such as: Harvard University, Bell Aircraft Corp., and Hamilton Standard Propellers ... for measuring natural frequencies or speed of rotating objects, checking or calibrating tachometers, oscillators, impulse generators, similar equipment.

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Please send *free* Stroboconn folder containing information about operation and application of this new precision instrument. I understand this places me under no obligation.

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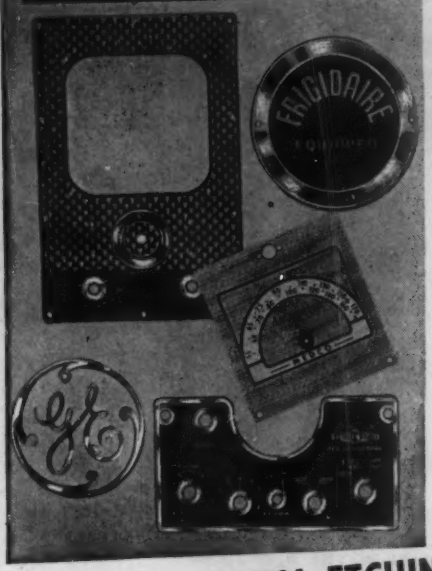

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Quality Products for Over 35 Years

—more compact, higher accuracy!

TYPES WL ⅝ and WLA ⅝

½ WATT INDUCTIVE

MAX. RES: .01 to 7,500 ohm (331 Alloy)
.01 to 4,000 ohm (Nichrome)
.01 to 1,250 ohm (Manganin)

BODY SIZE: ⅝" lg. by 3/16" diam.
TOLERANCE: STANDARD 1%

TYPES WL and WLA

1 WATT INDUCTIVE

MAX. RES: .01 to 15,000 ohm (331 Alloy)
.01 to 8,000 ohm (Nichrome)
.01 to 2,500 ohm (Manganin)

BODY SIZE: 1" lg. by 3/16" diam.
TOLERANCE: STANDARD 1%

Can be supplied non-inductive with one-half indicated maximum resistance.

IN-RES-CO
APPLICATION-DESIGNED
RESISTORS

Economical in Cost

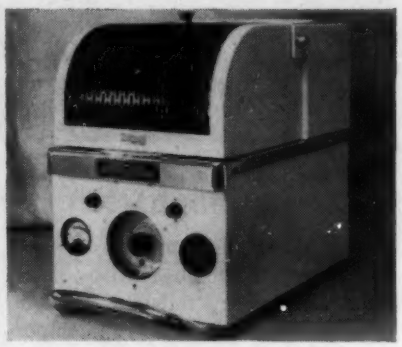
IN-RES-CO WL series resistors were designed to meet increasing demands for a compact resistor of high accuracy priced for general use. They meet the most critical requirements—close tolerance, ability to withstand overload, long life. Write today for catalog describing the full line of quality IN-RES-CO resistors.

INSTRUMENT RESISTORS CO., 1056 COMMERCE AVE., UNION, N. J.

which more than covers the present video frequency range. It operates on 117 volts, 60 cycles, and has a self-contained power supply. Price is $195.

Electronic Preheater

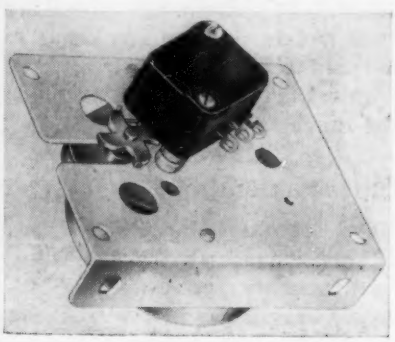
AMERICAN BRITISH TECHNOLOGY INC., 57 Park Ave., New York 16, N. Y. The Radyne medium-sized electronic preheaters are made in various sizes from 20 to 375 btu



output. Heating rate can be adjusted smoothly from zero to full power by arranging the electrode, raising and lowering a knob at the top of the cabinet. Heat output and timing are indicated by dials.

Flasher Timers

HAYDON MFG. CO., INC., 245 E. Elm St., Torrington, Conn., has designed the No. 5400 series of interrupter or flasher timers for applications requiring that current be fed to a controlled circuit in pulses of constant and predetermined ac-



6 NEW TERMINALS JOIN THE CTC LINE

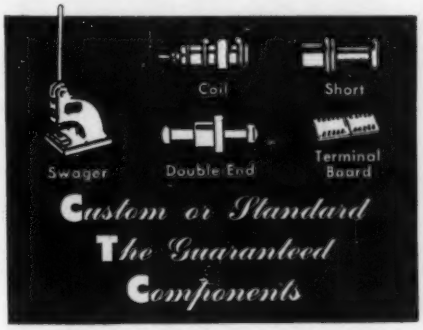
Hollow lugs speed wiring from top or bottom of terminal board.

Lugs shown actual size. Notice the midget split lug for hearing aids and other small-space applications. Ask for prices by code number.

These new CTC terminal lugs for quick, easy, neat connections are typical of the broad line in midget, short, turret, double-end and split types . . . in sizes to meet widely varying needs. They're all strongly made of quality brass, heavily silver plated; yet they're free from surplus metal that would draw heat and slow down soldering. Their tolerances are uniform enough for automatic swaging. And, of course, like all CTC components and hardware, they're guaranteed for materials and workmanship!

CUSTOM SERVICE

Chances are you'll find the terminal lugs you need in the CTC standard line. It's wise to check first. If not, CTC will custom-engineer lugs to your specifications. A discussion of your requirements will not obligate you in any way.

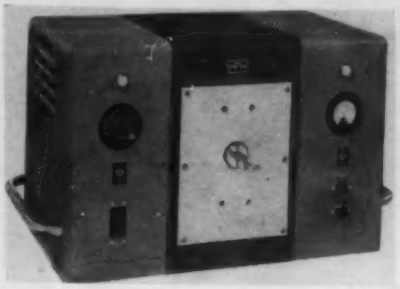


CAMBRIDGE THERMIONIC CORPORATION
437 Concord Avenue, Cambridge 38, Mass.

curacy. The range is from 72 flashes per minute, each 0.4 second in length, to 1 every 2 minutes, each flash 1 minute long.

Power Generator

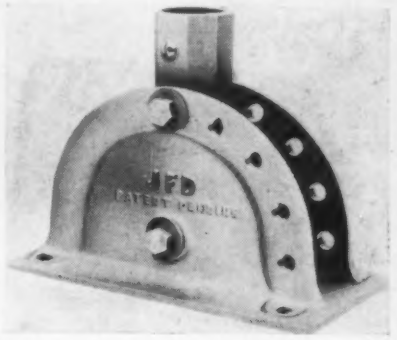
THE HIGH FREQUENCY HEATING CO., 143 Glen Park Ave., Gary, Indiana, announces the HFH-1.2A-L elec-



tronic power generator for production induction heating. Power output is 1,200 watts; frequency, 400 kc.

Antenna Bracket

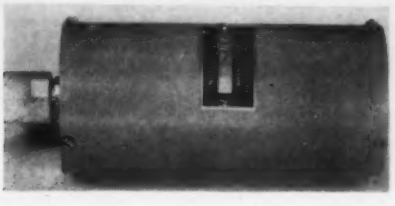
J. F. D. MFG. CO., INC., 4117 Fort Hamilton Parkway, Brooklyn 19, N. Y. The multiposition bracket for f-m and television antenna offers secure setting at whatever



angle the mast is mounted. Request booklet 248S for further information.

Broad Band Transformer

MEASUREMENTS CORP., Boonton, N. J. Model M-2.6 broad band transformer is designed for matching 72-ohm coaxial to 300-ohm balanced line in the range 40 to 220

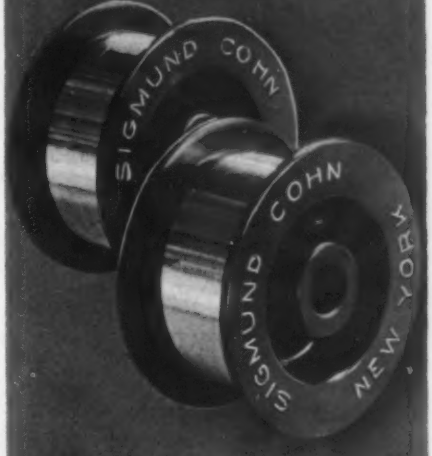


Wires drawn to .0004" diameter.

Ribbon rolled to .0001" thickness.

WIRE & RIBBON
MICRODIMENSIONAL
FOR VACUUM TUBES

Alloys for Special requirements.



WRITE for list of stock alloys.

SIGMUND COHN CORP.
44 GOLD ST., NEW YORK
SINCE 1901

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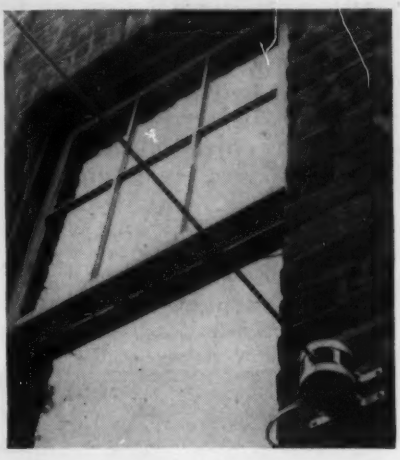
tube checker, each tube element has its own circuit switch. All standard receiver tubes as well as pilot bulbs and batteries can be checked.

Window Antenna

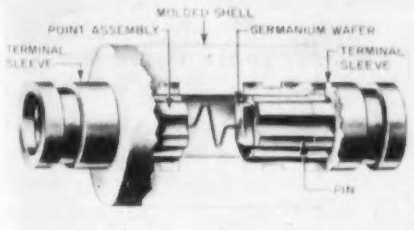
VERTROD CORP., 11 Park Place, New York 7, N. Y. Projecting not more than 45 inches a new television and f-m antenna can be



mounted outside an apartment or dwelling window. A network matches the antenna to 300-ohm line, although a special adapter can be furnished for 70-ohm line.

Germanium Varistors

WESTERN ELECTRIC CO., INC., 195 Broadway, New York 7, N. Y. Distributed by Graybar Electric Co., are several new types of point-

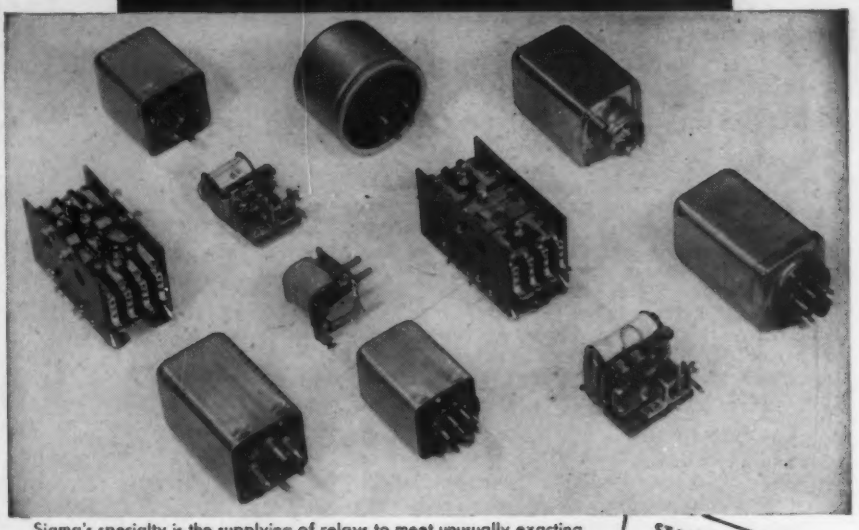


contact germanium crystals, 1N43, 1N44, 1N45, 1N46, 1N47, and D175347. They have low end-to-end capacitance, high current-handling ability, and stable characteristics.

Battery Voltmeter

HEWLETT-PACKARD CO., 395 Page Mill Road, Palo Alto, Calif. Battery-operated vacuum-tube volt-

HIGH PERFORMANCE *Relays*



Sigma's specialty is the supplying of relays to meet unusually exacting requirements. Such success as we enjoy is due as much to willingness to study applications in detail as to basically good relay designs.

You are urged to take advantage of this in submitting your problem, by stating particulars of purpose and function, permitting us to see the relay as part of a complete system.

STAMINA—ACCURACY —RELIABILITY— AT LOW COST

You can count on these features when you specify SIGMA RELAYS

SIGMA

Sigma Instruments, INC.

Sensitive RELAYS

62 Ceylon St., Boston 21, Mass.

● HIGH SPEED ● LOW INPUT
● LONG LIFE ● CLOSE TOLERANCE
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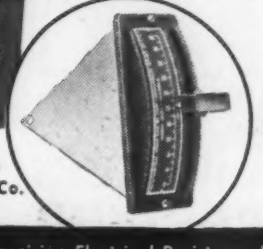
STATION WHKC ...Selects TECH LABS

VERTICAL ATTENUATORS

for new CONSOLE INSTALLATION

The flick of a finger operates the patented "Gove" Vertical Attenuator. Representing the very latest in broadcast components, these units are suitable for every type of sound equipment from elaborate broadcast stations to the simplest P.A. system. Unit gives smooth easy operation and can be cleaned from front of panel by removing escutcheon. Completely shielded and dust proof.



Courtesy of WHKC, United Broadcasting Co.

Write for Descriptive Bulletin

TECH LABORATORIES, INC.

Manufacturers of Precision Electrical Resistance Instruments

337 CENTRAL AVE. • JERSEY CITY 7, N. J.

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BRADLEY
RECTIFIERS

HIGH VOLTAGE
SELENIUM RECTIFIERS

Hermetically sealed in 1/2" diameter glass tubes, Bradley SE6M high voltage selenium rectifiers are rated up to 5 ma. D. C. They are polarized for fuse clip-type mounting. Available from 1,000 to 15,000 volts peak inverse. Bradley engineers can quickly specify the right type of selenium or copper oxide rectifier for your need.

PHOTO CELLS

SIMPLIFY PHOTO CELL CONTROL

Luxtron* photo cells convert light into electrical energy. No external voltage is required to operate meters and meter relays directly from Bradley photo cells, improving control over your processes, reducing your costs. Housed model shown. Many different sizes and shapes, mounted and unmounted.

* T. M. REG. U. S. PAT. OFF.

Illustrated literature, available on request, shows Bradley's full line of photo cells and copper oxide and selenium rectifiers.

Write for "The Bradley Line"

BRADLEY
LABORATORIES, INC.
82 Meadow St. New Haven 10, Conn.

megacycles. Type UG-21/U coaxial fittings and soldering lugs are provided.

Field Intensity Meter

RADIO CORP. OF AMERICA, Camden, N. J. A new portable field intensity meter type WX-2A contains a built-in calibrating oscilla-

tor and measures from 10 microvolts to 10 volts per meter in the frequency band from 540 to 1,600 kc. Readings are given directly making it unnecessary to use correction factors or charts.

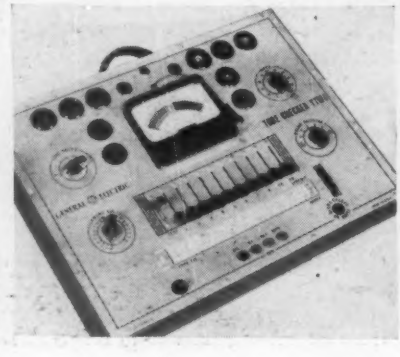
Acoustical Measurements

WESTERN ELECTRO-ACOUSTIC LAB. 621 S. Spring St., Los Angeles 14, Calif. The capacitor microphone unit type 100B illustrated and a

thermal noise source type 300A are available for acoustic measurements. Detailed specifications will be sent upon request.

Tube Checker

GENERAL ELECTRIC CO., Syracuse, N. Y. In the type YTW-1



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CONSULT JELLIFF

When confronted with any resistance problem, take advantage of the diversified experiences of Jelliff in selecting the proper alloys for your specific applications.

For recommendations, literature, prices and delivery of Jelliff Quality Alloys get in touch with our nearest sales representative or communicate direct with Southport, Connecticut. Write or phone for Prompt Action.

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CLEVELAND, OHIO Phone: MAIN 8585
A. J. Loeb Sales Co., 1836 Euclid Ave. So.

LOS ANGELES, CALIF. Phone: TRINITY 7353
Perlmuth-Colman Associates, 942 Maple Ave.

MINNEAPOLIS, MINN. Phone: GENEVA 3373
Volco Company, 622 McKnight Building

NEW YORK, N. Y. Phone: CALEDONIA 5-1776
R. B. Dana Company, 101 Park Ave.

PHILA., PA. Phone: KINGSLEY 5-1205
S. K. MacDonald, 1531 Spruce St.

PITTSBURGH, PA. Phone: CEDAR 3000
Wm. M. Orr Co., 1228 Brighton Rd.

ROCHESTER, N. Y. Phone: MONROE 5392
J. R. Hanna, P. O. Box 93, Brighton Station

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SOUTHPORT, CONN.

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ELECTRIC SOLDERING IRONS

that are sturdily built for the hard service of industrial usage. Have plug type tips and are constructed on the unit system, with each vital part, such as heating element, easily removable and replaceable. In 5 sizes, and from 50 watts to 550 watts.

American Beauty

TEMPERATURE REGULATING STAND

This is a thermostatically controlled device for the regulation of the temperature of an electric soldering iron. When placed on and connected to this stand, iron may be maintained at working temperature, or through an adjustment on bottom of stand, at low or warm temperature.

For further information, write 115-1

AMERICAN ELECTRICAL HEATER COMPANY
DETROIT 2, MICHIGAN
established 1894

into 10,000 ohms. With average use the batteries last three months.

Literature

Color Eye. Instrument Development Labs., Inc., 541 Willis Ave., Williston Park, L. I., N. Y. Type PPG-IDL Color Eye designed for industrial color measurements is pictured in a 4-page brochure. Detailed catalog sheets are also available.

New Motors. Eastern Air Devices, Inc., 130 Flatbush Ave., Brooklyn 17, N. Y., have a 4-page brochure describing Hysteresis synchonous motors for wire and film recorders, sound cameras, and other devices where lack of vibration and hunting is desirable.

Product Index. West Coast Electronic Manufacturers Association, Inc., 1161 North Vine St., Hollywood 28, Calif. A 20-page booklet contains the WCEMA membership list and also an alphabetical product list of radio lines manufactured and distributed on the West Coast. The bulletin is distributed without charge.

Sheet Metal Fabrication. Karp Metal Products Co., Inc., 129 30th St., Brooklyn, N. Y., has just published a 16-page, 2-color catalog outlining facilities for fabricating sheet metal cabinets and enclosures. Up-to-date examples are shown.

Broadcast Equipment Catalog. Radio Corp. of America, Camden, N. J. A-m, f-m, and television broadcast equipment is illustrated in a 247-page catalog that covers the field from microphones to measurement equipment. There is a convenient data section and index. Price is $1.00.

Standards List. American Standards Association, 70 E. 45th St., New York 17, N. Y. An up-to-date list of all approved national standards was recently published and is

EASY TO OBTAIN

in a wide range of types

YES, General Electric sockets—widely stocked—are as conveniently available as G-E tubes. You get the same fast delivery, plus leading-manufacturer responsibility to back up the product.

And G-E sockets are designed and built for G-E tubes! By standardizing on both, you have increased assurance of superior performance and high-value tube life.

Ordering is easy, from your nearby G-E source of tube-and-socket supply. One phone-call starts both items on their way to you, and your record-keeping is simplified.

Economically priced, G-E sockets in all popular types await your inquiry. Address your nearest G-E electronics office, or *Electronics Department, General Electric Company, Schenectady 5, New York.*

183-G4-8850

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ALTEC LANSING

adopts new policy of publishing

FREQUENCY RESPONSE CURVES

ALTEC LANSING CORPORATION

To be an honest yardstick of the performance of a speaker, frequency response curves must be scientifically accurate: they must be made on measurement equipment that has earned the approval of conservative unbiased audio scientists. The frequency response curves published by Altec Lansing to confirm the radically superior performance of its new 1948 line of speakers were made in its outdoor measurement laboratory at Encino, Cal., with equipment and methods approved and used by nationally known engineers as well as by the Motion Picture Research Council for establishing speaker standards in the motion picture industry. *The dependability of curves is a measure of the professional integrity of the manufacturer who releases them.*

Methods and equipment for outdoor-automatic high speed measurements are those recommended by the American Standards Association in their Loudspeaker Testing Bulletin (C16.4-1942) and refined by Altec Lansing Research Staff.

Send for brochure describing 1948 line of Altec Lansing speakers, containing frequency response curves. Altec Lansing Corporation, 161 Sixth Ave., New York 13, or 1161 North Vine St., Hollywood 38, Calif.

The Shape and Size YOU need!

PARAMOUNT SPIRAL WOUND PAPER TUBES

SEND FOR ARBOR LIST OF OVER 1000 SIZES

Inside Perimeters from .592" to 19.0"

Convenient. Helpful. Lists great variety of stock arbors and tube sizes. Includes many odd sizes. Write for Arbor List today.

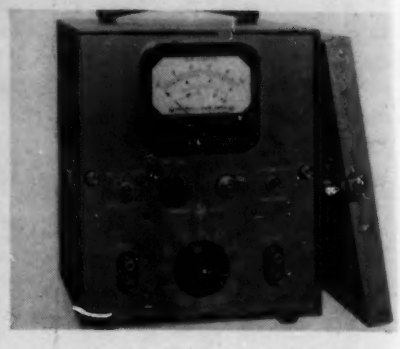
All Sizes In Square and Rectangular Tubes

Leading manufacturers rely on the quality and exactness of PARAMOUNT paper tubes for coil forms and other uses. Here you have the advantage of long, specialized experience in producing the exact shapes and sizes for a great many applications. *Hi-Dielectric, Hi-Strength.* Kraft, Fish Paper, Red Rope, or any combination. Wound on automatic machines. Tolerances plus or minus .002". Made to your specifications or engineered for YOU.

PARAMOUNT PAPER TUBE CORP.

616 LAFAYETTE ST., FORT WAYNE 2, IND.

Manufacturers of Paper Tubing for the Electrical Industry



meter model 404A is designed for a-c measurements from 2 cycles to 20 kilocycles at voltages ranging from 0.001 to 300 volts. Input impedance is 10 megohms shunted by capacitance of approximately 20 picofarads.

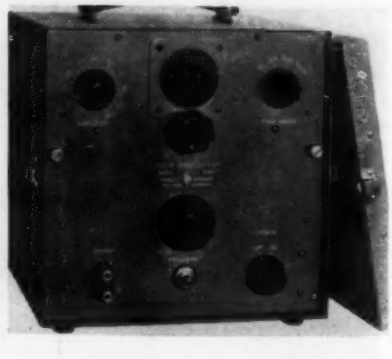
Pickup Preamplifier

GENERAL ELECTRIC Co., Syracuse, N. Y. A new phonograph preamplifier UPX003 designed for use

with a variable reluctance pickup is equipped with power transformer and rectifier, avoiding the necessity for connecting the device into the receiver wiring.

Battery Audio Oscillator

HEWLETT-PACKARD Co., 395 Page Mill Road, Palo Alto, Calif. Model 201A audio oscillator has a frequency range from 2 cycles to 20 kc in 4 decades. Output is 5 volts



now available free of charge. The new price list is useful to manufacturers, consumer groups and government agencies.

Dieless Duplicators. O'Neil-Irwin Mfg. Co., Lake City, Minn. A new 40-page catalog lists benders, parters, shears, brakes, and other metal working equipment.

Connector Catalog. Cannon Electric Development Co., Humbolt St. and Avenue 33, Los Angeles 31, Calif., recently issued the 32-page C-47 edition of its condensed catalog. It covers the thirteen major type series of multicontact electric connectors for radio, aircraft and communications.

Miniature Fluorescents. Stocker and Yale, 48 Birch St., Marblehead, Mass., shows an interesting line of small fluorescent lamps for microscope and similar illumination in a new 4-page illustrated folder. Included are combined lights and magnifiers.

Blowers. Rotron Division, Jenckes Knitting Machine Co., 180 Weeden St., Pawtucket, R. I. Catalog sheets RP-24 and RM-22 give description and technical information on a new line of small, centrifugal blowers with high pressure performance, as required for the cooling of many of the new forced air cooled radio transmitting tubes.

Voltage Regulation. Sorensen & Co., Inc., 375 Fairfield Ave., Stamford, Conn. Catalog S-348 describes in detail electronic control of voltages and currents. Photos of applications, circuit diagrams and efficiency and performance curves for a line of a-c and d-c voltage regulators are given.

Components Catalog. P. R. Mallory & Co., Inc., 3029 E. Washington St., Indianapolis 6, Ind. This recently completed catalog Number 1 covers a line of products including capacitors, rectifiers, resistors, switches, vibrators, metals and alloys, contacts and resistance weld-

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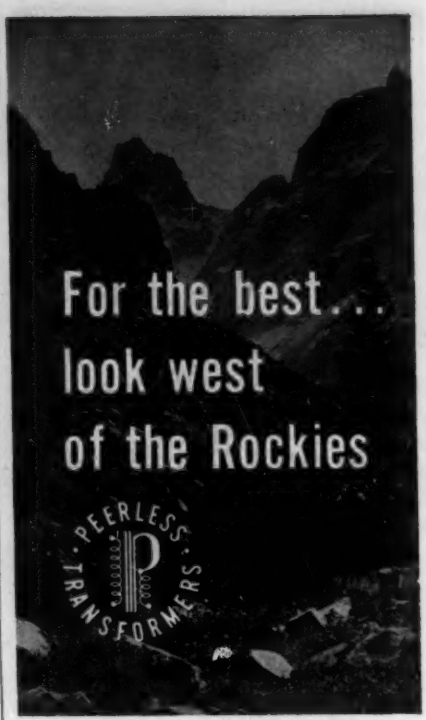

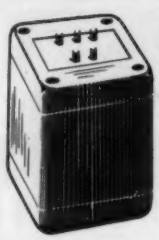

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PEERLESS ELECTRICAL PRODUCTS DIVISION

ALTEC
LANSING CORPORATION

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Frazar & Hansen, Ltd., 301 Clay St., San Francisco 11, exclusive export agent

ing. The 80-page publication is available on request by manufacturers.

Supersonic Reflectoscope. Sperry Products, Inc., 1505 Willow Ave., Hoboken, N. J. Testing of welds in plate, thin sheet and other sections with the superonic reflectoscope, using a new angle transmitter, is fully described in sales data sheet 3021.

Towers. Rostan Corp., 202 East 44th St., New York 17, N. Y. Characteristics of three types of towers are given in a single-page catalog sheet, together with a list of suggested uses.

Broad-Band Antenna. Communications Co., Inc., 300 Greco Ave., Coral Gables, Florida. Information is available on the model 244 high-gain, broad-band antenna designed for communication with mobile units on frequencies above 100 mc.

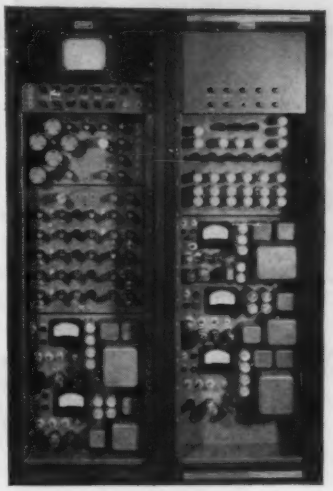
Position Recorder. Servo-Tek Products Co., Inc., 4 Godwin Ave., Paterson, N. J. The Servograph is a graphic recorder having a circular chart with an inking pen which is remotely controlled by the use of synchros. A four-page folder tells how it works, gives specifications and applications.

Conductive Coatings. E. I. du-Pont de Nemours & Co., Electrochemicals Dept., Wilmington 98, Delaware. Conductive coatings for printed circuits, high-voltage capacitors, static shielding, and other uses are described in bulletin CP-2-1247.

Parts Catalog. Aircraft Radio Corp., Boonton, N. J. A booklet comprising a series of bulletins replete with mechanical drawings, specifications, and illustrations covers test equipment, microwave accessories and electronic component parts.

Lightning Protection. L. S. Brach Mfg. Corp., 200 Central Ave., Newark 4, N. J. Important considerations relative to the role

TEST TV TRANSMISSION
★ and RECEPTION ★



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SYNC GENERATOR
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Monoscope Picture Generator
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Produces regular pictures used with TV transmitters. Gives synchronizing, driving and blanking signals for testing, research and development work, with monoscope controls and distribution signals for use at various points of testing.

Invaluable to manufacturers of TV receivers and broadcasting units for checking faults not likely to be observed by other methods. Can be used at transmitting stations as auxiliary unit. Available either in combination or as separate units.

Now used exclusively by many leading manufacturers of television equipment.

Send for this illustrated monograph completely describing the new Telequip Sync Generator and Monoscope.

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Kepco Laboratory Multiple Power Supply Model 103, available separately.

Kepco Electronic Instruction Panel Model 104, available separately.

Now you can perform electronic experiments simply, easily with the Kepco Electronic Instruction Panel. Here is a teaching aid that graphically illustrates vacuum tube principles — enables all students to grasp fundamentals in the laboratory.

Extremely versatile, the Kepco Electronic Instruction panel covers a wide range of tubes, comes with a packet of 23 keyed interchangeable circuit charts, 3 master charts and 12 blank keyed sheets for additional experiments. Panel contains 3 octal tube sockets, 18 binding posts. By placing a keyed circuit diagram on the panel and wiring the circuit, students determine tube or circuit characteristics.

For a basic electronic instructional aid that vastly simplifies the teacher's task, it's the Kepco Electronic Instruction Panel!

Now you can eliminate the use of cumbersome separate voltage supplies with the Kepco Laboratory Multiple Power Supply. Designed to be used with the Kepco Electronic Instruction Panel, this versatile, compact, easy-to-use unit supplies four commonly used voltages, is invaluable for the school or industrial laboratory.

CHECK THESE FEATURES:
Two continuously variable B supplies, adjustable from 0-300 volts at 120 m.a.
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All connections made to sturdy, front panel binding posts.
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Two 5Y3 rectifiers, Two 6Y6 control tubes.
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Solves many problems by reproducing on oscillograph screen an accurate picture of explosion or pressure variations related to factors of time, angular velocity, peak and top dead center pressures, crankshaft, carburetor and exhaust actions, etc.

Quickly pays for itself in operation and maintenance savings. Now used by leading engine, aircraft and automobile manufacturers, oil companies, chemical plants and refineries, military and naval ordnance, etc.

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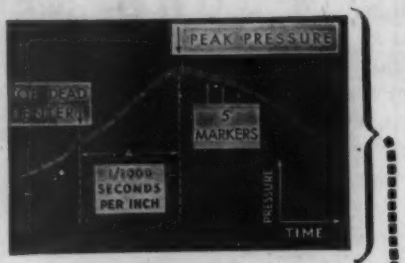
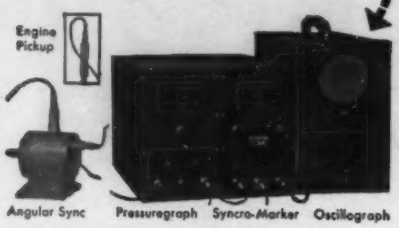


Know your pressure variations and you know how to increase engine, pump or pressure line efficiency.



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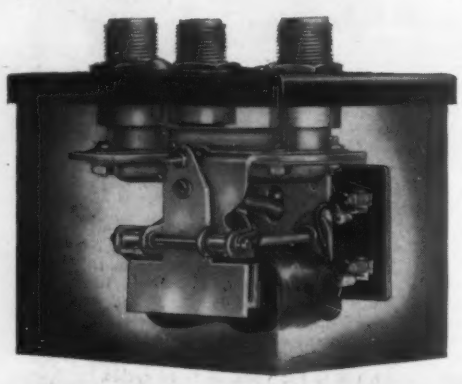
COAXIAL RELAY

FOR HIGH FREQUENCY SWITCHING



Double coil electro-magnets provide increased power for extra high contact pressures, insuring positive contact under vibration conditions.

Actuating rod of special molded composition floats in ball and cup end bearings. Armature provided with oilite bearings, with stainless steel pin, insuring mechanical life of several million operations.

Contact arm construction provides wiping action in both transmit and receive positions.

Bulletin C6 upon request

SIGNAL ENGINEERING & MFG. CO.

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played by lightning arresters in radio, police and fire alarm, railroad signal, telephone and telegraph circuits are discussed in Catalog 48-A. A complete line of arrester and terminal facilities and accessories is treated.

Storage Battery Research. Gould Storage Battery Corp., Trenton 7, N. J. A new 16-page, fully illustrated brochure introduces a new and complete research laboratory. Among the items featured are raw materials specification and testing, instantaneous voltage measurement and the proving of products of research.

Instrument Recording Materials. Eastman Kodak Co., Rochester 4, N. Y. A 4-page catalog describes eleven films and papers used to record oscillograph traces and similar phenomena. A graph shows variety in speed, contrast, color sensitivity and other specifications as determined by particular instruments.

High-Speed Photography. Eastman Kodak Co., Rochester 4, N. Y. Applications of the high-speed camera to industry are described in a 12-page booklet. Information is given concerning operating characteristics and the accessories commonly used.

Predetermined Counters. Production Instrument Co., 710-12 W. Jackson Blvd., Chicago 6, Ill. Bulletin ES-91 is a 16-page illustrated booklet showing the application of electric and electric-eye counting to the requirements of modern industry. Examples given include devices for counting parts, cartons, mechanical operations and folding machine production.

Relay Selection. Allied Control Co., Inc., 2 East End Ave., New York 21, N. Y. The new relay guide illustrates a complete line of twenty-four small, compact, relays of varied types and features. A detailed table enumerates the specifications of each relay. Copies are available upon request.

An Announcement

OF IMPORTANCE TO ALL

MANUFACTURERS

OF RADIO EQUIPMENT

HOWARD W. SAMS' LABORATORIES NOW AVAILABLE FOR COMPLETE PREPARATION OF SERVICE DATA MANUAL FOR MANUFACTURERS

The active demand, cooperation and encouragement of many manufacturers in the industry, has brought about the creation of the Howard W. Sams' Manufacturers' Division. The full facilities of the Sams' laboratories are now available to manufacturers of A.M., F. M. and Television Receivers; Record Changers; Recorders; Inter-Communication units; Power Amplifiers; and kindred electronic equipment, for the preparation and publication of service manuals.

This new service offers you the preparation of complete, accurate, logical service data, relieving your service and engineering divisions of burdensome detail, and effecting significant economies in preparation and printing costs.

Our staff of service engineering specialists are ready to prepare from thorough analysis of the actual equipment, the following data: Text material, covering construction, operation, installation and service procedures compilation of parts lists and specifications; clear, accurate schematic diagrams based on the exclusive PHOTOFACT "Standard Notation" system; "exploded" views and full photographic coverage of the product. Production experts supervise the final preparation and publication of data.

NOW SERVING THESE CLIENTS:

We are at present serving a considerable industry group. Service manuals and data have been satisfactorily prepared (with many others in work):

Brush Development Co.
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Crescent Industries
Emerson Radio & Phonograph
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Specimens of our work are available on request. Your inquiries are invited. Our representative will gladly call on you to explain the entire service. Address your inquiries to our Manufacturers' Division.

HOWARD W. SAMS & CO., INC.
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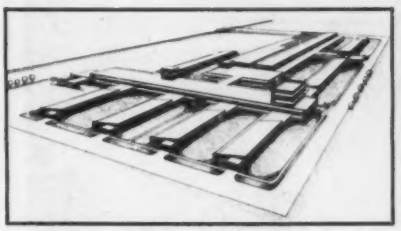
Publishers: PHOTOFACT Folder Sets and Volumes, "Automatic Record Changer Service Manual"; "Dial Cord Stringing Guide"; "Radio Receiver Tube Placement Guide." Other Volumes in preparation. Complete data on request.

mathematics, electronics, metallurgy, propulsion systems for rockets and missiles, and fire control and guidance systems. Research is under the direction of L. T. E. Thompson, who is aided by a large staff of scientists and technical personnel.



Artist's sketch gives aerial view of Michelson Laboratory in heart of Mojave Desert

BUSINESS NEWS

WESTERN ELECTRIC CO., manufacturing and supply unit of the Bell System, has arranged to purchase a 130-acre industrial site for the construction of a manufacturing plant at Indianapolis, Ind.

BROWN INSTRUMENT CO., Philadelphia has begun a $2,500,000 expansion program which includes the construction of new five-story building on foundations designed to support four additional floors.

CROWN CAPACITOR CORP., 316 Stuart St., Boston, Mass., was recently formed to produce a line of fixed paper capacitors.

NATIONAL RESEARCH CORP., Cambridge, Mass., has granted an exclusive license to Smith Paper, Inc., Lee, Mass., for the production of metallized paper for use in electrical capacitors.

MACHINE O'MATIC CO., electronic control and attachments manufacturer, recently moved from Flushing, N. Y. to Ashley, Ohio.

ALLEN B. DU MONT LABORATORIES, INC., Passaic, N. J., recently demonstrated a system called tele-transcription for transcribing television shows on film. This opens the way for a new type of television net-

Made with exacting care Red Streak Acid-Free tapes and gummed flat sheets are made to conform to the most critical specifications and are uniform throughout. Tests for free acids and alkalines are made by P H method. Available in materials and thicknesses below.

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.003-.004-.005-.006-.007-.010 Kraft
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work—a network by tele-transcriptions made by filming video programs off the face of a c-r tube.

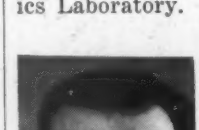
RCA INTERNATIONAL DIVISION has concluded an agreement with the Societe des Lamps Fotos, whereby American-type radio tubes will be manufactured in volume in France.

WESTINGHOUSE ELECTRIC CORP. and PHILCO CORP. will establish a joint radio and television center in the Westinghouse-KYM building, Philadelphia, Pa.

PERSONNEL

CHARLES F. STROMEYER, vice-president of the Hytron Radio and Electronics Corp., Salem, Mass., is the new president of Remco Electronics, Inc., New York City.

CARROLL STANSBURY, holder of 54 patents in the fields of motor control, industrial electronics and resistance welding, has been appointed to the electronics division of the National Bureau of Standards, where he will do research work in the Engineering Electronics Laboratory.



C. Stansbury

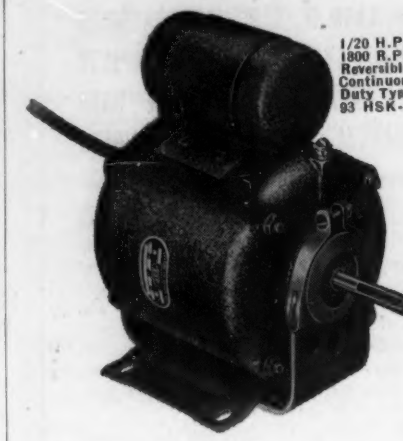
H. E. Rhodes

HOWARD E. RHODES, formerly vice-president and chief engineer at Aerovox Corp., was appointed chief engineer of the new capacitor plant of Sangamo Electric Co. at Marion, Illinois.

RICHARD HODGSON was recently appointed director of technical operations for the television division of Paramount Pictures Inc.

DONALD G. WILSON has been named chairman of the department of electrical engineering at the University

NEW
Hysteresis
SYNCHRONOUS
MOTORS



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Applications:

Disc, wire and film recorders
Sound cameras and projectors
Facsimile equipment
Television equipment
Timing devices
Stroboscopic work
Teletype equipment

The hysteresis design of this new Synchronous Motor lowers noise and vibration level to a fraction of that normally present in conventional salient pole construction.

A most important advantage is its ability to synchronize independently of inertia present in the load. Unaffected by the inertia, the H. P. required need only to be sufficient to drive the frictional component of the load.

Supplied in round frame, resilient mount and rigid base.

1/50 H.P. and 1/100 H.P. ratings in a smaller frame size are available. Write for particulars.

EASTERN AIR DEVICES, INC.
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BROOKLYN 17, NEW YORK

of Kansas. In 1942 he joined a group at the MIT radiation laboratory doing research on means of propagating microwaves.

CARL MAURER, with the Paramount television division for the past four years, has been advanced to supervisor of development engineering.

MURRAY G. CROSBY, former research engineer for RCA and later a member of the firm of Paul Godley Co., consulting engineers, has opened a radio-electronic consulting and development laboratory under the name of Crosby Laboratories, 126 Old Country Road, Mineola, N. Y.

M. G. Crosby

B. B. Bauer

B. B. BAUER, formerly director of engineering, was recently appointed vice-president of Shure Brothers, Inc.

SIDNEY DAVIDSON, a member of the NBC engineering staff since 1945, has been named studio supervisor of WPIX (Channel 11), The News television station in New York.

WILLIAM J. KELLY, NBC engineer since 1931, has joined WPIX as transmitter supervisor.

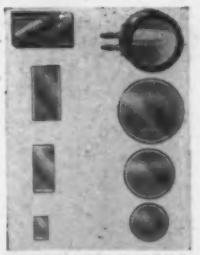
ROBERT M. MORRIS, after 12 years as administrative head of television engineering operations for NBC, has been appointed engineer in charge of television for the American Broadcasting network's Central Division.

DOUGLAS H. EWING, previously manager of Teleran Engineering, was appointed manager of all advanced development engineering at RCA Engineering Products Department, Camden, N. J.

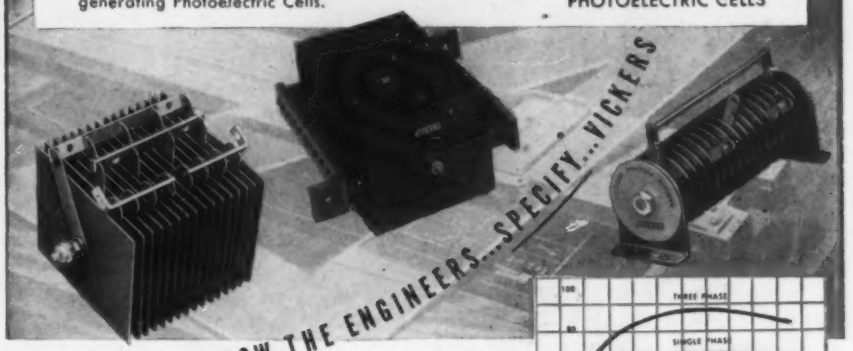
CHARLES R. SCHMIDT, formerly electronic engineer with Finch Facsimile, Curtiss Wright and Federal

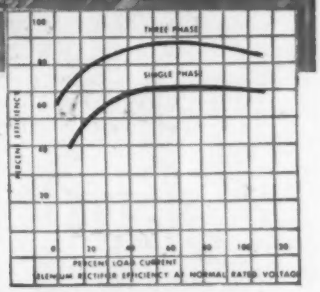
LINKING FUNCTION TO DESIGN

Engineers and Designers who insist on dependable components have adapted Vickers Selenium Rectifiers into their circuits. They are specifying Vickers products, and are submitting their rectifier problems to us. Our greatly expanded plant facilities, plus the recognized dependability of Vickers products, make it possible for us to offer the most complete line of Selenium Rectifiers and self-generating Photoelectric Cells.



PHOTOELECTRIC CELLS





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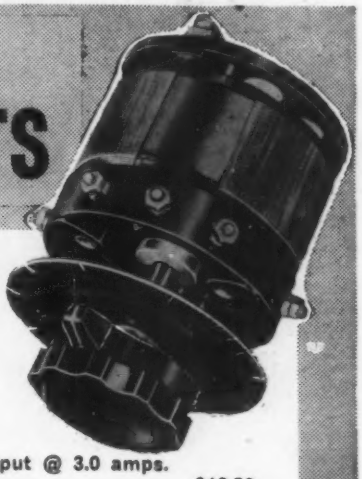
VICKERS ELECTRIC DIVISION

VICKERS INC.

2160 EAST IMPERIAL HIGHWAY • EL SEGUNDO, CALIF.

EXPORT: Frazar & Hansen, Ltd., 301 Clay St., San Francisco 11, Calif.
CANADA: Powertronic Equipment Ltd., 494 King St., E. Toronto 2, Canada

SUPERIOR POWERSTATS



For precise Voltage Control—the "Superior" line of variable transformers stands at the top of the list. It is "Superior" in performance — "Superior" in mechanical construction — "Superior" in design and durability.

VARIABLE TRANSFORMERS

TYPE 20: 115V. input, 0-135 V. output @ 3.0 amps. 0.4 KVA	$12.50
TYPE 116: Mounted; 115V input, 0-135 V. output @ 7.5 amps. 1.0 KVA	23.00
TYPE 116U: Unmounted; 115V. input, 0-135 V. output @ 7.5 amps. 1.0 KVA	19.00
TYPE 1126: 115V. input, 0-135 V. output @ 15.0 amps. 2.0 KVA	46.00
TYPE 1226: 230V. input, tapped at 115 V., 0-270 V. output @ 9.0 amps. 2.4 KVA	46.00
TYPE 1156: 115V. input, 0-135 V. output @ 45.0 amps. 6.1 KVA	118.00

If not rated 25% with order, balance C.O.D. All prices F.O.B. our warehouse New York. We ship to any part of the globe. Write Dept. EL

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KNOW ACTUAL RF POWER FED TO FM ANTENNA—WITH *Micro-Match*

Glancing at Micro-Match Model MM-200 indicator unit at WTHT's new FM transmitter is Charles S. Masini, Chief Engineer of station. Above, coupler unit in standard 1⅝" dia. coaxial line.

Micro-Match gives you direct, continuous accurate reading in kilowatts. Also gives precise, continuous reading of SWR of antenna system. Thus at a glance you are assured of the proper functioning of the complete RF portion of your transmitter and of your atenna system and transmission line.

MICRO-MATCH models available for operation at 500 KC to 250 MCS, and power levels of 2 to 50,000 watts.

Write for complete descriptive literature

M. C. JONES ELECTRONICS COMPANY

96 North Main Street — Bristol, Connecticut

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COOLER OPERATION

KOTRON
STRIP-TYPE
SELENIUM RECTIFIERS

PATS. PEND.

100 MA. UNIT

- Max. A. C. line input 130 volts rms
- Max. inst. peak current 1000 Ma.
- Max. inverse peak voltage 360
- Average operating temp. 105°F
- Dimensions: 4-1/16" x 1-1/16" x 5/32"
- Other Sizes: 75 Ma. and 200 Ma.

Kotron's metallic rectifying elements are mounted in one plane. Plates cannot contribute heat to each other. Result—Cooler Operation . longer life . . . increased circuit efficiency. Wafer-thin Kotron saves space, mounts easier.

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Telephone and Radio, is now assistant chief engineer at Airlectron Engineering Co., Caldwell, N. J. He will take charge of new product development in electronic instrumentation.

SIMON RAMO, formerly with G-E, has been appointed Research Associate at California Institute of Technology and is now also director of guided missile development at Hughes Aircraft Co., Culver City, Calif.

WILLIAM R. AHERN, associated with General Electric since 1941 as engineer in the television equipment division, was appointed an engineer in the facilities section of the American Broadcasting Company's engineering department in New York.

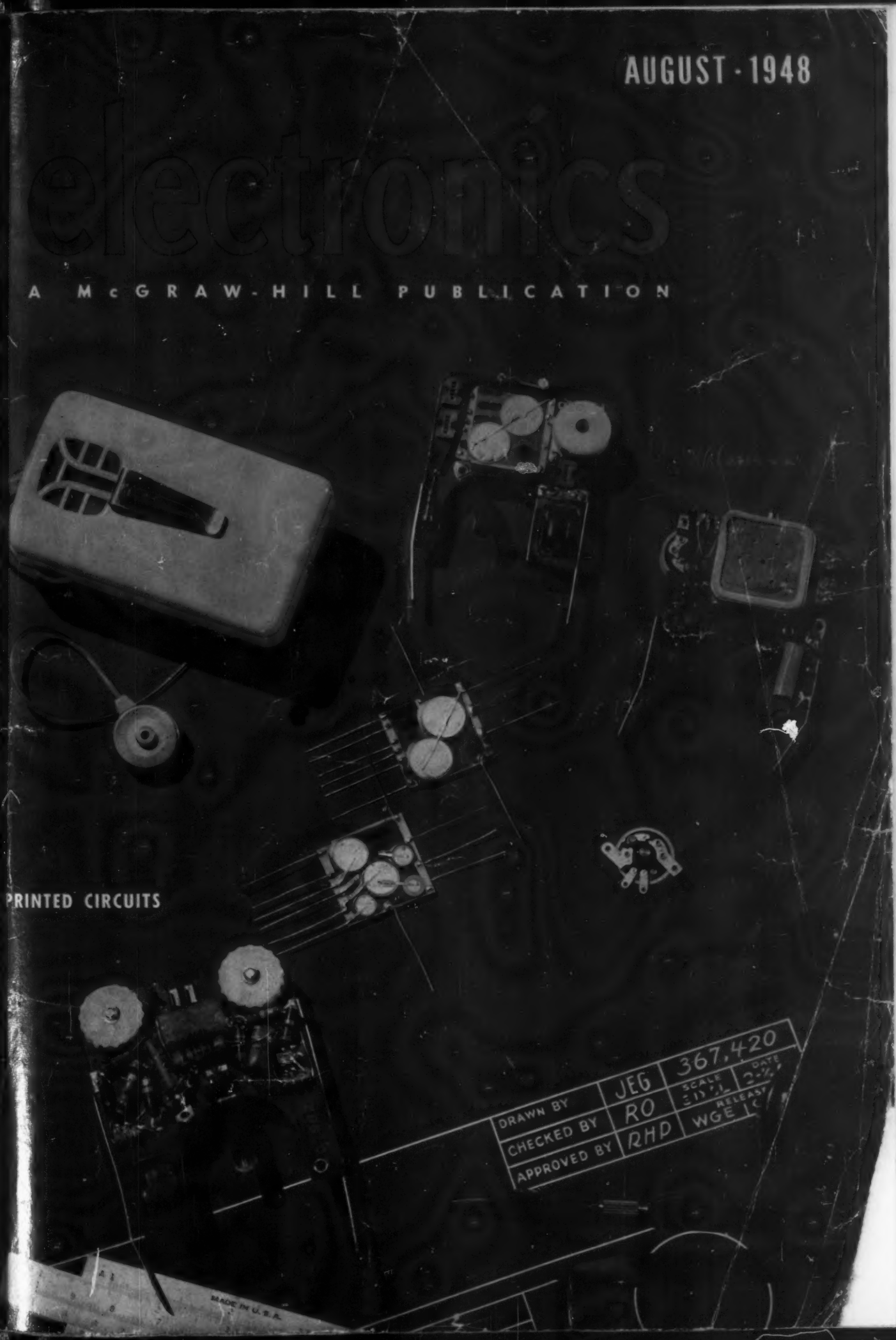
DONALD L. HERR, formerly officer in charge of the U. S. Naval Shipyard surge project at Terminal Island, Calif., has joined the engineering staff of Allen-Bradley Company of Milwaukee, Wisc., to develop servomechanisms for machine tool and other motor controls.

KARL SPANGENBERG, professor of electrical engineering at Stanford University and formerly technical consultant with the OSRD, has been granted a leave of absence for a year to direct the electronics activities of the Office of Naval Research.

GEORGE R. BASTEDO, previously associated with the development of guided missiles for the U. S. Navy, has been appointed to the staff of the National Bureau of Standards as electronics engineer for the Guided Missile Section.

N. F. SHOFSTALL, with G-E for nearly 20 years, was recently named division engineer in charge of all engineering for the Receiver Division at Electronics Park in Syracuse.

JOSEPH STROCKBINE is the new supervisor in charge of transmitter maintenance at WPIX. He has been in the transmitter department of RCA at Camden, N. J. since 1940, and has tested every RCA television transmitter produced to date, including the RCA TT-5A which is being installed in the Daily News Building.



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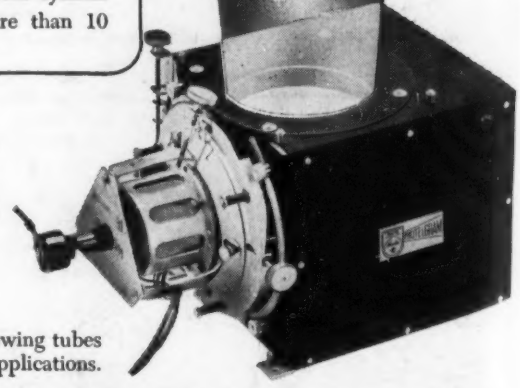

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Miniature components and wiring fired onto ceramic plate (*center*—front and rear views) permit simplification of hearing-aid design (*top*—front and rear views). Equivalent conventionally wired chassis is shown at lower left for comparison. Photo by Moni Hans Zielke for Centralab

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